THERMAL BELTS AND
FRUIT GROWING IN NORTH CAROLINA

Harvey J. Cox

W. B. No. 796

U. S. DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

MONTHLY WEATHER REVIEW

SUPPLEMENT No. 19

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THERMAL BELTS FROM THE HORTICULTURAL VIEWPOINT

By W. N. Hutt, Former State Horticulturist

Submitted for publication February 7, 192~~3~~2.

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SUPPLEMENTS TO THE MONTHLY WEATHER REVIEW.

During the summer of 1913 the issue of the system of publications of the Department of Agriculture was changed and simplified so as to eliminate numerous independent series of Bureau bulletins. In accordance with this plan, among other changes, the series of quarto bulletins—lettered from A to Z—and the octavo bulletins—numbered from 1 to 44—formerly issued by the U. S. Weather Bureau have come to their close.

Contributions to meteorology such as would have formed bulletins are authorized to appear hereafter as Supplements of the MONTHLY WEATHER REVIEW. (Memorandum from the Office of the Assistant Secretary, May 18, 1914.)

These Supplements comprise those more voluminous studies which appear to form permanent contributions to the science of meteorology and of weather forecasting, as well as important communications relating to the other activities of the U. S. Weather Bureau. They appear at irregular intervals as occasion may demand, and contain approximately 100 pages of text, charts, and other illustrations.

Owing to necessary economies in printing, and for other reasons, the edition of SUPPLEMENTS is much smaller than that of the MONHLY WEATHER REVIEW. SUPPLEMENTS will be sent free of charge to cooperating meteorological services and institutions and to individuals and organizations cooperating with the Bureau in the researches which form the subject of the respective supplements. Additional copies of this SUPPLEMENT may be obtained from the Superintendent of Documents, Washington, D. C., to whom remittances should be made.

The price of this Supplement is 50 cents.

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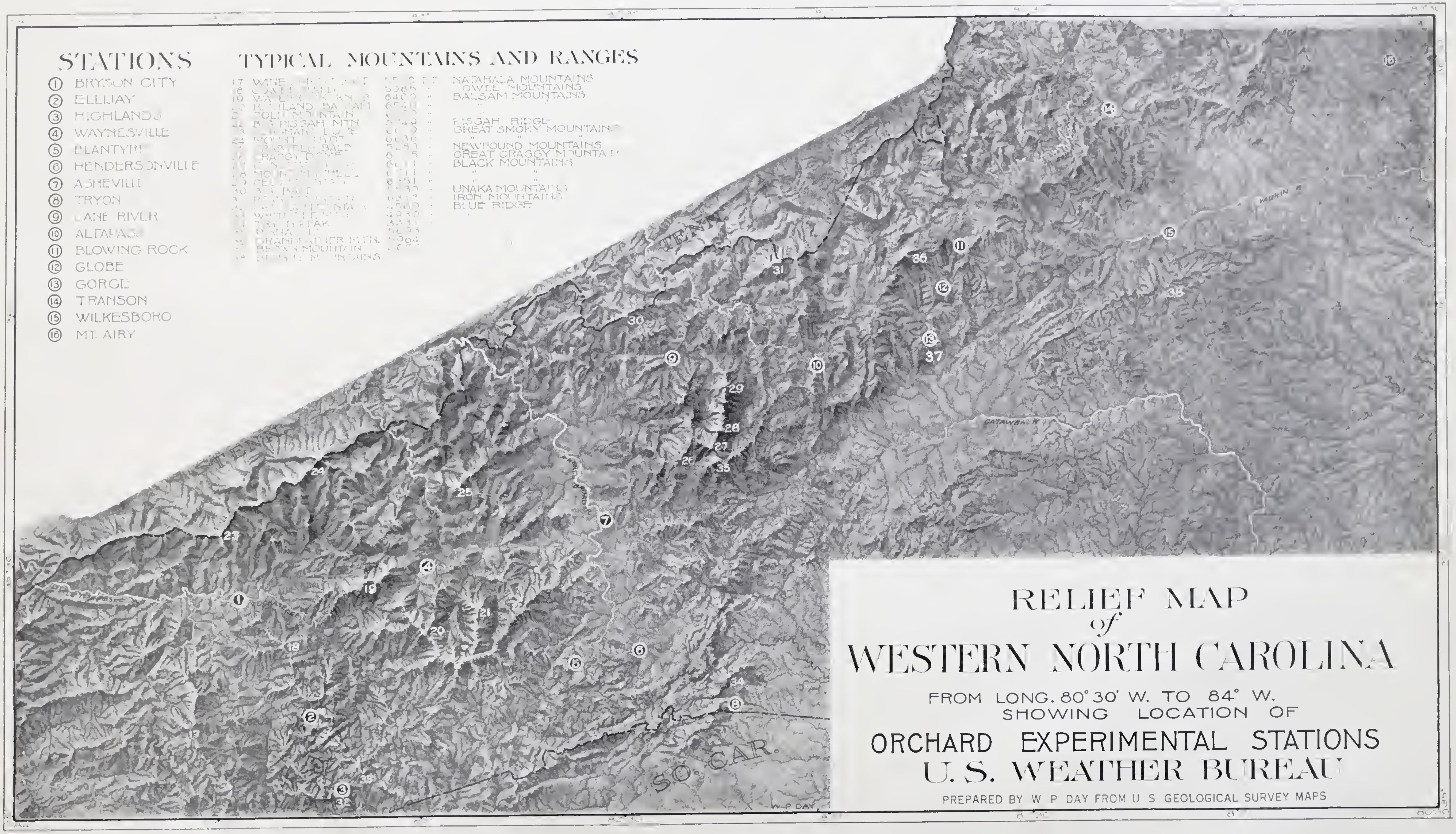

STATIONS
① BRYSON CITY
② ELLIJAY
③ HIGHLANDS
④ WAYNESVILLE
⑤ BLANTYRE
⑥ HENDERSONVILLE
⑦ ASHEVILLE
⑧ TRYON
⑨ LANE RIVER
⑩ ALTAPASS
⑪ BLOWING ROCK
⑫ GLOBE
⑬ GORGE
⑭ TRANSON
⑮ WILKESBORO
⑯ MT. AIRY
TYPICAL MOUNTAINS AND RANGES
NATAHALA MOUNTAINS
OWEE MOUNTAINS
BALSAM MOUNTAINS
PISGAH RIDGE
GREAT SMOKY MOUNTAINS
NEWFOUND MOUNTAINS
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UNAKA MOUNTAINS
IRON MOUNTAINS
BLUE RIDGE
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FROM LONG. 80° 30' W. TO 84° W.
SHOWING LOCATION OF
ORCHARD EXPERIMENTAL STATIONS
U. S. WEATHER BUREAU
PREPARED BY W. P. DAY FROM U. S. GEOLOGICAL SURVEY MAPS

THERMAL BELTS AND FRUIT GROWING IN NORTH CAROLINA.

Henry J. Cox, Meteorologist.

ACKNOWLEDGMENTS.

Acknowledgment is made of the assistance of Prof. Charles F. Marvin, Chief, U. S. Weather Bureau, who in his former position in charge of the Instrument Division, cooperated to the fullest extent in supplying instrumental equipment for the observations, and who later advised as to the scope of the research and reviewed the manuscript, offering many helpful suggestions. Acknowledgment is made to Prof. A. J. Henry, U. S. Weather Bureau, who reviewed and edited the manuscript and gave much time to an examination of the tables, maps, and graphs.

The assistance of those who have taken part in this investigation is also hereby acknowledged: Mr. E. H. Haines, U. S. Weather Bureau, performed the work in the field and assisted in the compilations and in the preparation and discussion of the material; Mr. W. P. Day, U. S. Weather Bureau, prepared the illustrations and assisted in the compilations and in the preparation and discussion of the material; Mr. L. A. Denson, U. S. Weather Bureau, made the installations of the stations and gave personal attention to the instrumental equipment during the period of the research; Mr. W. M. Hutt, formerly State Horticulturist, North Carolina, offered suggestions and advice, with special reference to the horticultural side of the research; Mr. F. R. Baker, Drainage Engineer, North Carolina Department of Agriculture, made surveys of the slopes upon which the experimental stations were located and prepared the original topographical maps. Acknowledgment is also made of the courtesies extended by the owners of the various orchards or other properties in which the experimental stations were operated and of the cooperation of the individual observers.

A vast amount of tabulated data has been prepared, but the number of tables published has necessarily been greatly reduced for want of space.

INTRODUCTION.

A research (upon the thermal conditions in the North Carolina mountain region) was inaugurated in 1912 by the United States Weather Bureau at the request of the North Carolina State Board of Agriculture and the State Horticulturist, with a hope that the so-called Thermal Belts might be more clearly defined, and that safe elevations in the various sections for the planting of fruit trees might be determined, as far as possible.

Considerable success had been obtained in many portions of that region in the growing of hardy fruit, especially apples, but here and there marked failures had occurred, supposedly because either of too great altitude or of unfavorable topography, inducing freezes in the one case and severe frosts in the other.

Heretofore the planting of orchards in the mountain region had been carried on in a rather haphazard way, so far as the influence of temperature conditions was concerned, and it was believed by the State Horticulturist that an exhaustive study of the various problems might furnish valuable information for the guidance of orchardists in the development of their properties.

The special meteorological stations that were established in the North Carolina mountain region for the purpose of this study at points shown in relief map in frontispiece were conducted under the direction of the Weather Bureau, while the State Horticulturist has afforded assistance with advice and suggestions.

Reference has frequently been made in meteorological and climatological literature to thermal belts or frostless zones in mountain districts, both in this country and in Europe. These belts, of varying width in which frost is never observed, were said to be found on certain slopes between the valley floor and the summit, their development being mainly due to the fact that during certain cool nights the temperature is relatively high on the slope—much higher than at the base.

This phenomenon, termed the inversion of temperature, is observed most frequently on clear, quiet nights, but sometimes on partly cloudy and even cloudy nights. It is called an "inversion" because ordinarily we expect a fall in temperature with elevation, which, for the want of a better name, we may here term a "norm" in contrast with the term "inversion." On the average the temperature of the free air falls with height, the mean rate of decrease being 1° F. in 300 feet of ascent, and there are many nights in the mountain region when this decrease in temperature with elevation or even a greater one is observed, especially when the weather is cloudy and windy. There are still other nights, moist and damp, when the differences in temperature between various elevations are hardly appreciable.

Both inversions and norms prevail within mountain valleys to a considerable vertical height, and are important factors in the question of fruit growing. In the one case the minumum temperature is lowest at the base and highest at some point on the slope or at the summit, while in the other case the minimum is lowest at the summit and highest at the base; and, through a combination of these two conditions, we sometimes have a belt more or less indefinite in width where the minima average higher than at either the base or the summit, free from the frosts of the valley and from the freezes of the higher levels. Within this belt, which might properly be called a "verdant zone," the foliage is fresh and green as compared with that above and below.

DESCRIPTION OF REGION.

More has probably been written regarding thermal belts in the North Carolina mountains than in any other section of the country, doubtless because the phenomena are more pronounced there than elsewhere in the East on account of the more extensive slopes and the greater area. The Appalachian Mountains, which form the divide between the great central valleys of the United States and the Atlantic Plain, extend in a southwest-northeast direction from Pennsylvania to northwest Georgia, but the culminating section of the system lies in western North Carolina. While the elevation of the Atlantic Plain at the base of the mountains is only 150 feet in Pennsylvania, and perhaps 500 feet in Virginia, in North Carolina it rises to about 1,000 feet.

The Appalachians divide into two chains in Virginia, one known as the Great Smokies, continuing in its southwesterly course and forming the boundary of western North Carolina, and the other, retaining the name of the Blue Ridge, as the range in the north is called, crossing the State farther eastward and forming the great watershed of the drainage of that section. Between the two chains lies a remarkable region of valleys and plateaus, at no point falling to a lower elevation than 2,000 feet, while portions of the plateau in Watauga County to the north and Macon County to the south have elevations ranging from 3,500 to 4,000 feet. Within this system scores of mountain peaks rise to an altitude of more than 5,000 feet, and many even more than 6,000 feet, Mount Mitchell being the highest, with an elevation of 6,711 feet.

The North Carolina mountain region, then, is preeminently a land of high mountains and plateaus, and because of its elevation it is known as the "Land of the Sky," a region most irregular in shape, having an area of over 5,000 square miles and extending in a northeast-southwest direction, about 125 miles.

In a general view the eastern chain, or Blue Ridge, is seen to be irregular and fragmentary, while the western chain, the Great Smokies, is more regular, elevated, and continuous. Nevertheless, the drainage of the plateau between the two is thrown entirely to the westward. Numerous cross chains uniting the main ranges form basins which contain the mountain tributaries of the Tennessee River. Projecting into the Piedmont region east of the Blue Ridge are a few detached chains and isolated knobs.

The principal streams of the mountain region rise in the Blue Ridge, and those trending westward break through the more elevated western barrier in deep chasms, the French Broad, the North Toe, and the Pigeon, all three flowing into the Tennessee; and the Tuckasegee, into the Little Tennessee; while those on the other side of the

average

ridge trending eastward are the Yadkin, emptying into the Pee Dee River, and the Catawaba, separated from the Yadkin by the Brushy Mountains and flowing first easterly and then southerly through the Piedmont region into the Atlantic.

The mountains are for the most part covered with timber up to their very summits, even Mount Mitchell having considerable forest growth at the highest points; but there are a few peaks, termed "Balds," with elevations of 5,000 feet or more, whose rounded knobs are almost bare of timber.

The relief map in the frontispiece shows the general topography of the region.

temperature and elevation above mean sea level of the base stations.

Taking temperature conditions in the sections to the east of the mountains as a basis, there is normally, because of the difference in latitude, about 2° difference in the mean annual temperature between the northern and southern limits of this mountain region. In the lower levels the isotherm of 59° F [1] runs somewhat south of the Virginia-North Carolina border, while that of 61° is approximately in line with the Georgia-North Carolina boundary. Temperature data for the summits of the highest mountains in North Carolina are not available, but the means deduced from the observations at places

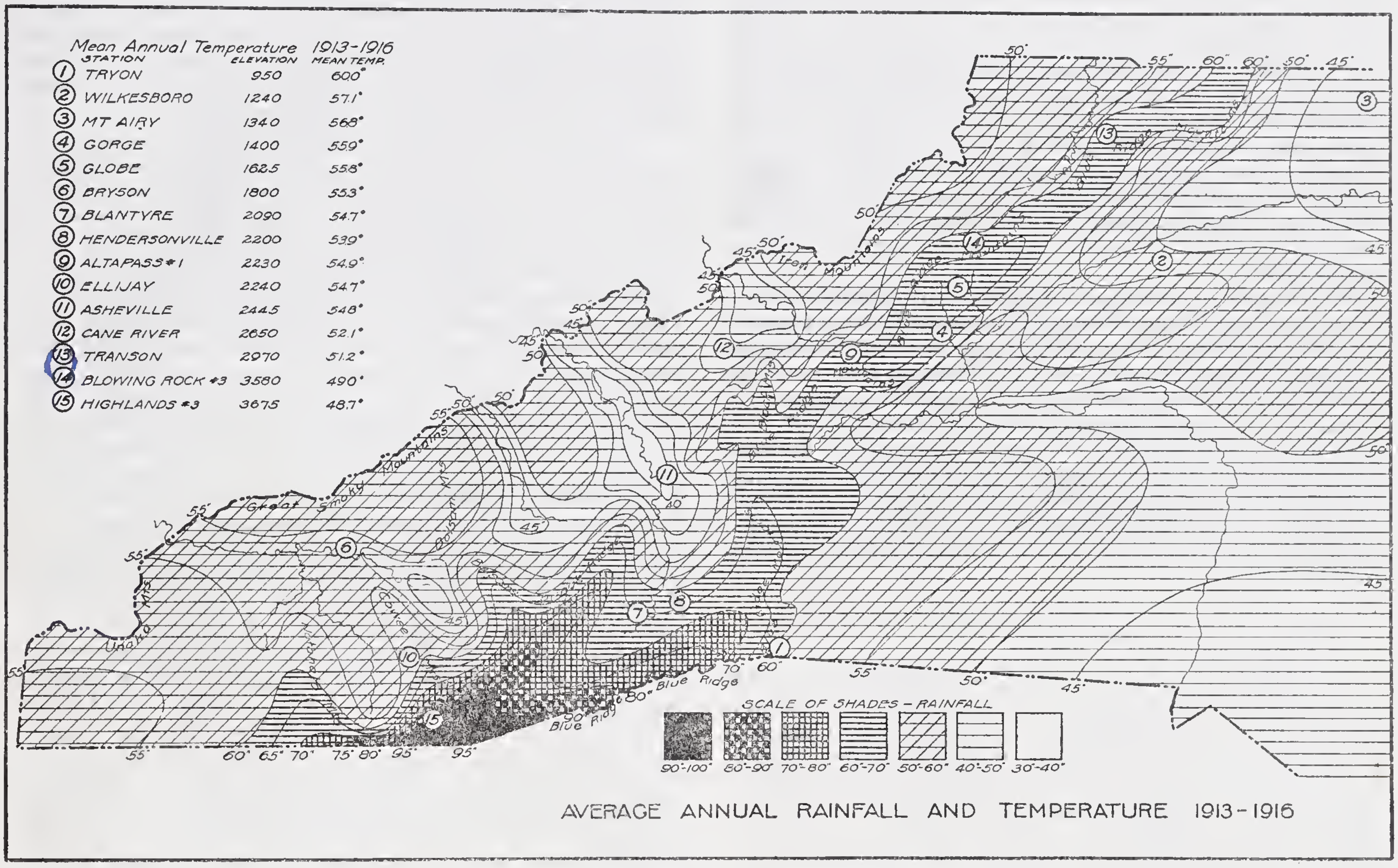

FIG. 1.—Average annual rainfall and temperature, western North Carolina, 1913–16.

GENERAL TEMPERATURE AND RAINFALL CONDITIONS IN REGION AS AFFECTED BY ELEVATION.

The modifying effect of elevation on the general meteorological conditions of the region is twofold—viz, a reduction in temperature and an increase in rainfall. The isotherms as they approach from the eastern lowlands curve southward rapidly and, after crossing the mountains more or less irregularly at right angles, bend sharply northward, while the rainfall is much greater in the mountain region than at the lower levels, and is greatest over the more elevated sections, especially those on the side of the mountains facing the rain-bearing winds.

Figure 1 gives the average annual percipitation over western North Carolina for the four years 1913–1916. Isotherms for the same period are also shown and in the upper left-hand corner will be found a key to the location of the observing stations, also the mean annual

having altitudes up to 4,000 feet are sufficient to show strikingly the effect of elevation upon temperature. The lowest annual mean for a considerable period in the mountain region is 49° at Blowing Rock and Highlands, both about 3,600 feet above sea level, the first in the extreme northwestern portion and the other in the extreme southwestern portion of the State. Because of the difference in latitude, Blowing Rock should normally average 2° colder than Highlands, but this variation is not apparent in the observations because of the difference in topography, the station at the latter place being located in a well-marked frost pocket where the night temperature averages uniformly low. This mean annual temperature of 49° is approximately the mean of the Weather Bureau station at Albany, N. Y., where the thermometer shelter stands about 100 feet above sea level.

[1] Fahrenheit degrees and English units are used throughout this discussion.

The rainfall in the Carolina mountain region, as shown in Figure 1, varies considerably and it is generally much heavier than on the Atlantic Plain. The largest amounts occur along the main Blue Ridge, especially on its southern and eastern sides, as the principal rain-bearing winds in that section are from east to south. The southerly winds carry the moisture-laden air from the Atlantic and the Gulf of Mexico, and naturally the greatest rainfall is recorded at the stations farthest to the south, where these east to south winds, moving inland, pass upward over the slopes, the cooling of the air resulting in condensation, often excessive. During a four-year period, 1913-1916, inclusive, the gauge at Highlands registered an average annual precipitation of 97.86 inches, the total in 1915 being 111.21 inches, and in 1916, 105.10 inches, two extremely wet years. In the same period the cooperative station at Rock House, formerly known as Horse Cove, (Fig. 7), about six miles southeast of Highlands, recorded an average rainfall of 94.62 inches. These figures are considerably above the average for a long period of years, which are, respectively, 80 and 82 inches, but in any case this spot in the mountain region close to the North Carolina-Georgia boundary is the wettest place in the United States except the extreme northwest Pacific coast.

The rainfall over the Great Smokies is much less than along the Blue Ridge, because the southerly and easterly rain-bearing winds are shut off, or at least their moisture is largely condensed over the Blue Ridge before reaching the Smokies. Moreover, the rainfall on the plateau inclosed by these two mountain ranges is very much less than on the surrounding mountains, obviously because of the condensation of a large portion of the moisture at the higher levels before the winds reach the plateau. Asheville, in the valley of the French Broad River and walled in by mountains has an average annual rainfall of only 39 inches.

SCHEME OF WORK AND DISTRIBUTION OF STATIONS.

Although the special research was inaugurated in 1912, it was not until the first part of 1913 that all the stations selected were in full operation. Stations were installed at 16 places in the mountain region, Bryson, Ellijay, Highlands, Waynesville, Blantyre, Hendersonville, Asheville, Tryon, Cane River, Altapass, Blowing Rock, Globe, Gorge, Transon, Wilkesboro, and Mount Airy. Bryson is the most westerly, Mount Airy, close to the Virginia border, the most northerly and easterly, and Highlands and Tryon, close to the Georgia and South Carolina borders, respectively, the most southerly. At the 16 points of of observation there was a total of 68 stations, varying at each point from 3 to 5. The point having the greatest elevation is Highlands, where the stations range from 3,350 feet to 4,075 feet in altitude, and the lowest is Tryon, its base station having an altitude of only 950 feet. Six of the slopes, Ellijay, Tryon, Cane River, Altapass, Globe, and Gorge, have differences in elevation between base and summit of 1,000 feet or more, the longest slope, 1,760 feet, being at Ellijay. Some of the slopes are steep, and others are gentle, irregular, and broken up into coves and frost pockets. Some are heavily timbered, while others are comparatively free from forest growth, just as certain of the individual stations are surrounded by dense vegetation while others are more or less bare.

At one point, Asheville, the stations were located above a valley floor on two slopes, northerly and southerly, facing each other, while at two other places, Bryson and Mount Airy, the stations were on slopes leading down from different sides of knobs. Nearly all the short slopes lead up to isolated knobs, also some of the longer ones, and in other cases there is a large extent of surface area near the summit. Some of the valleys at the base of the slopes are narrow and confined, and others are comparatively broad; again, some base stations are located on broad benches. A wide range of conditions has thus been afforded for investigation.

The places were fairly well distributed geographically, all being located in the main portion of the mountain district with the exception of Wilkesboro and Mount Airy, which lie in the foothills to the east. Two places, Blowing Rock and Altapass, are on the main Blue Ridge. There was no definite uniformity observed in determining the positions of the stations on the individual slopes, the exact locations in some cases being dependent upon conditions beyond the control of the leader, the purpose being to place at least one or two stations in each group within an orchard, when one was available.

The task of selecting locations for the stations was rather difficult. The purpose was, of course, to make as complete a survey as possible of the meteorological conditions in the mountain region. The scope of the work, however, had its limitations because of the difficulty in securing and training competent observers and because of the impracticability of locating stations in some cases where most desired. To do the observation work with absolute completeness, experienced observers should have been located at many elevated points well-nigh inaccessible; but this was, of course, impracticable. The bureau was obliged to select places where men were available to take observations, generally superintendents or foremen employed in the orchards, and these men had to be trained as observers, the observation work being incidental and in addition to their regular duties.

The places selected were for the most part on slopes having orchards already planted, the number of stations at each place averaging four. For purposes of convenience the stations were numbered in consecutive order from the base to the summit, station No. 1 being on the valley floor, or at least at the base of the particular slope, and stations Nos. 3, 4, or 5, as the case might be, at the summit, or as far up as practicable. In some places, where there was a further descent below the base, as at Altapass, the No. 1 station was not placed actually on the valley floor; while at a few places, as at Asheville, the highest station was not at the summit, the location in each case being governed by the exigency of the situation.

The observations continued at all 16 places until the close of 1916, with the exception of Waynesville, where the work was terminated in the middle of the period. The data at that place, on account of this interruption, have consequently not been included herein. For the sake of uniformity and convenience, the dicussion of the observations in this research is limited to the four years, 1913-1916.

The individual stations were furnished with thermometer shelters containing thermographs and maximum and minimum thermometers, these instruments being placed about 5½ feet above the ground; and one station in each place, called the "home station," was supplied with a minimum thermometer attached to the outside of the shelter, a sling psychrometer, and a rain gauge. This home station was the one nearest to the residence of the observer—at some places at the base, at others on the slope or even on the summit, depending upon the convenience of the particular point to the observer's residence. At the home stations the observa-

tions were made and the thermometers set daily, while at the other stations the readings were made twice a week only, the thermograph traces, however, furnishing a continuous record. However, the data at the home stations are more complete and dependable than at the others. In addition to the instrumental record of temperature and precipitation, data as to wind direction and estimated velocity, especially at sunrise and sunset, and notes as to the character of the weather during both day and night were kept by the observers. The regular equipment at Tyron was supplemented by a hygrograph at station No. 3.

There were not available at any of the special stations instrumental records of wind or sunshine, but the records of the regular Weather Bureau station in the city of Asheville have been used to supplement the observations made in the field. Asheville is fortunately located in the very center of the region under investigation, and one group of orchard experimental stations was established a few miles distant from the city.

Moreover, the observations made by the orchard observers were supplemented in the spring of 1916 by special work at Ellijay, Highlands, Tryon, and Blowing Rock by Mr. E. H. Haines, of the Chicago Weather Office, and in the spring of 1915, at Ellijay and Highlands by Prof. H. H. Kimball and Mr. R. N. Covert, of the Central Office at Washington. Professor Kimball's observations[2] have already been published.

TOPOGRAPHY OF THE INDIVIDUAL SLOPES AND THE EXPOSURE OF THE INSTRUMENTS.

A complete description of the conditions under which the instruments were exposed is essential to an understanding of the observations, and detailed statements regarding the environment of each group of stations will be found with the contour maps of the respective stations. It is important to know whether the slope is steep or gentle, whether regular or broken up into coves and pockets; also its height above the base and above sea level, the direction of its inclination, its general environment as regards topography and vegetation—in a word, to know every condition that might possibly affect the temperature, rainfall, humidity, or wind. It will be found later, as the observations are discussed, that exposure and environment have a most important bearing upon the situation.

The stations are not located necessarily at the exact points where the numbers appear in the relief map, because these numbers are entered at the positions of the various cities or villages, while in many instances the experimental stations are a few miles distant. This variation will be explained under the description of each group of stations, and the special contour maps and accompanying profiles will show in detail the local topography at each place. The profiles indicate the vertical distances between the base and the summit stations and the vertical and horizontal distances from station to station. As stated previously, the lowest, or base station, is always numbered 1, while the highest in the group has been numbered 3, 4, or 5, as the case may be, depending upon the number of stations employed.

In the descriptions of the stations and their exposures, only important features are mentioned; but these, at least, are necessary to an understanding of the observations.

The shaded portions of the topographical maps indicate cleared areas in the vicinity of the observation stations.

The arrangement of the stations is from west to east, following the numbers on the relief map which forms the frontispiece.

[2] Kimball, H. H., Nocturnal Radiation Measurements, MONTHLY WEATHER REVIEW, February, 1918, 46: 57-60.

BRYSON.

Capt. A. M. Frye, Observer.—A group of four stations in the orchard of the observer, about 2 miles northeast of the village of Bryson and 1½ miles north of the Tuckasegee River, on the valley floor of Deep Creek in a region hemmed in on the north by the spurs and ridges of the Great Smokies and on the south by the Yalaka Mountains; mountains at varying distances tower above on nearly all sides. Base station, No. 1, 1,800 feet above sea level, in a grass plot on a flat plain with the country in the immediate vicinity rolling and broken. Station No. 2, in a cove or gully 385 feet above and in a horizontal direction 3,000 feet northeast of station No. 1; in the midst of apple orchard, the trees being a few feet from the shelter on all sides; on northerly slope separated from station No. 1 by a knob, the summit of which is about 400 feet southwest of station No. 2. No. 2a, home station, on south slope 385 feet above station No. 1; same elevation as station No. 2, but over the hill and on the opposite side; shelter in midst of orchard close to apple trees; ascending slope on all sides, except gradually descending on south side between two hills; timber to south and west about 100 feet distant. Station No. 3 on a small knob 570 feet above station No. 1; not in orchard; shelter surrounded by ferns and scrub oaks; also high timber to the south and southwest 15 to 20 feet and to the east 30 feet distant; sharp descent to orchard below. The slope in the orchard, as a rule, is quite gradual. The vertical distance between stations Nos. 1 and 3 is 570 feet, and the horizontal distance is 3,000 feet, a grade of 12°.

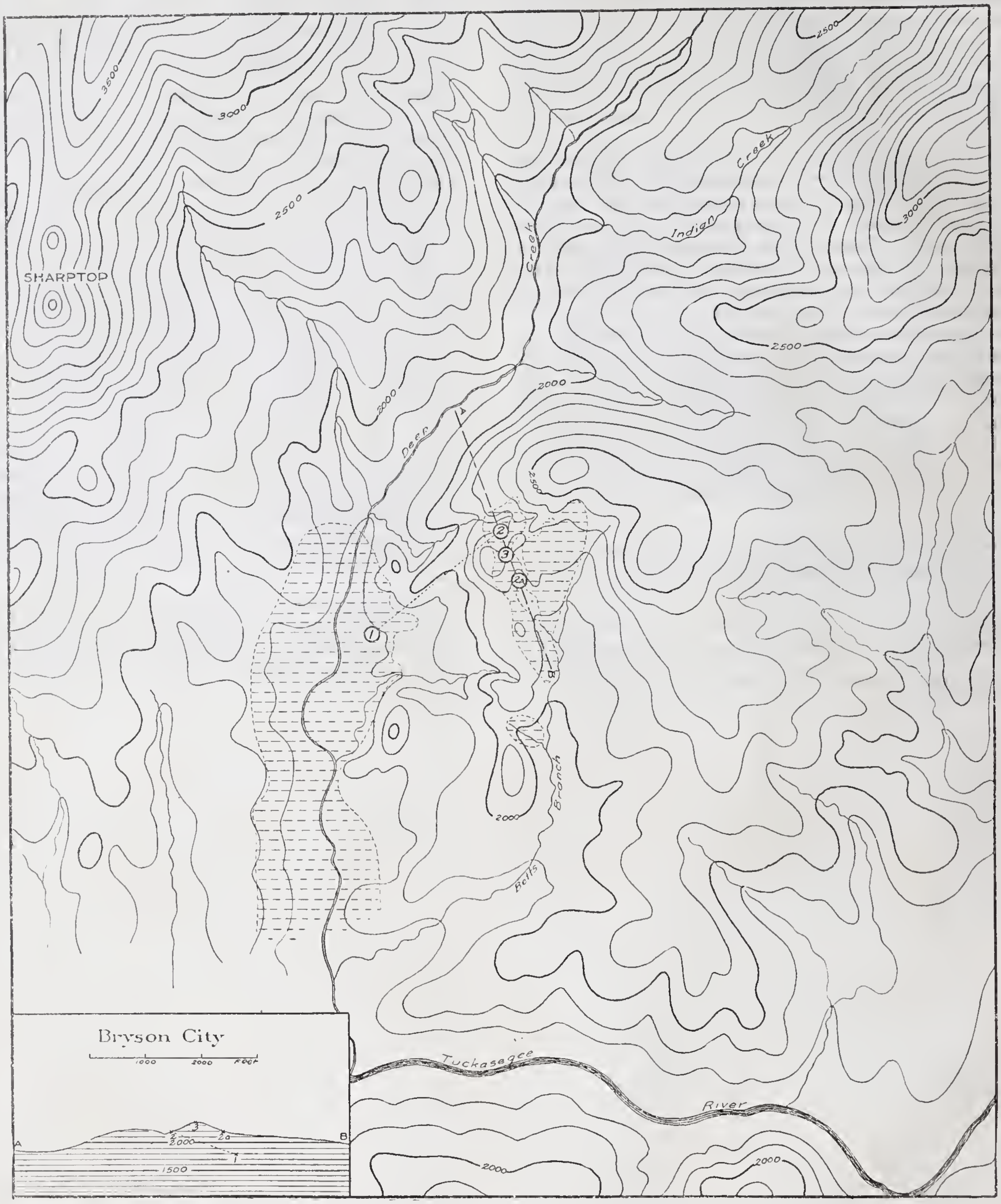

FIG. 2.—Bryson, contour map and profile.

FIG. 4.—Station No. 5, Ellijay.

FIG. 5.—Slope, north side, Ellijay Creek, facing research stations, and showing snow line of April 9, 1916.

FIG. 7.—Cooperative Weather Bureau station, Rock House, N. C. (near Highlands).

FIG. 8.—Station No. 3, Highlands—coldest of all stations.

FIG. 10.—Station No. 1, Blantyre, on State farm directly below a northeast slope of French Broad River.

FIG. 11.—Station No. 2, Blantyre, on State farm in sag at base of Little Fodderstack Mountain

FIG. 12.—Stations Nos. 3 and 4, Blantyre, in orchard of State farm on Little Fodderstack Mountain.

FIG 14.—Station No. 1, Hendersonville.

FIG. 15.—Station No. 2, Hendersonville.

FIG. 16.—Station No 3, Hendersonville.

FIG. 18.—North slope in orchard near Asheville, looking down valley.

FIG. 19.—Northerly slope of orchard in which stations Nos. 2 and 3 are located

FIG. 20.—Southerly slope opposite orchard, station No. 2a in center; station No. 3a above No. 2a obscured by timber

Fig. 22.—Station No. 1, Tryon, on valley floor Pacolet River, Warrior Mountain in background

Fig. 23.—Warrior Mountain, Tryon, showing location of stations Nos. 2, 3, and 4.

Fig. 24.—Station No. 3, Tryon, on slope above vineyard.

Fig. 27.—Station No. 2, Altapass. Photographed February 28, 1916.

Fig. 28.—Station No. 4, Altapass; orchard on steep slope.

Fig. 29.—Station No. 5, Altapass, on grass plot on summit, orchard on left and below

FIG. 31. Grandfather Mountain from Blowing Rock.

FIG. 32.—Flat Top orchard, Blowing Rock, stations 3, 4, and 5.

FIG. 33.—Portion of Flat Top orchard from station No. 4, Blowing Rock, looking southeast, small lake in foreground, above which is station No. 3.

FIG. [illegible].—South slope of orchard at Valle Crucis, near Blowing Rock.

FIG. [illegible].—Sparger orchard, Mount Airy, station No. 1 [illegible].

FIG. [illegible].—Sparger orchard, station No. 1, Mount Airy, [illegible].

ELLIJAY.

Chas. G. Mincy, Observer.—The Ellijay stations, on the property of the observer, on a steep northerly slope of a spur of the Cowee Mountains, the base station, No. 1, being in the valley floor of Ellijay Creek at an elevation of 2,240 feet, while the high station, No. 5, is on the summit of a knob 1,760 feet above the base and 4,000 feet above sea level. Station No. 1, in a field about 30 feet south of the creek, over grass plot, at a considerable distance from any trees; across creek to the north, station No. 1, over sod in apple orchard on moderate slope though steeper above and below, slope broken up into ridges and hogbacks. Station No. 4, 1,240 feet above station No. 1, in clearing and on edge of steep northerly slope, in corn and potato patch; brush about 16 feet to the west; some timber 100 feet to the west and southwest. In winter sun shut off during greater part of day. Station No. 5, 1,760 feet above station No. 1, a level field near the summit of a high knob, another prominence, Peak Knob, 180 feet higher than station No. 5, distant 1,800 feet to the south; timber to the west, southwest and south, mostly

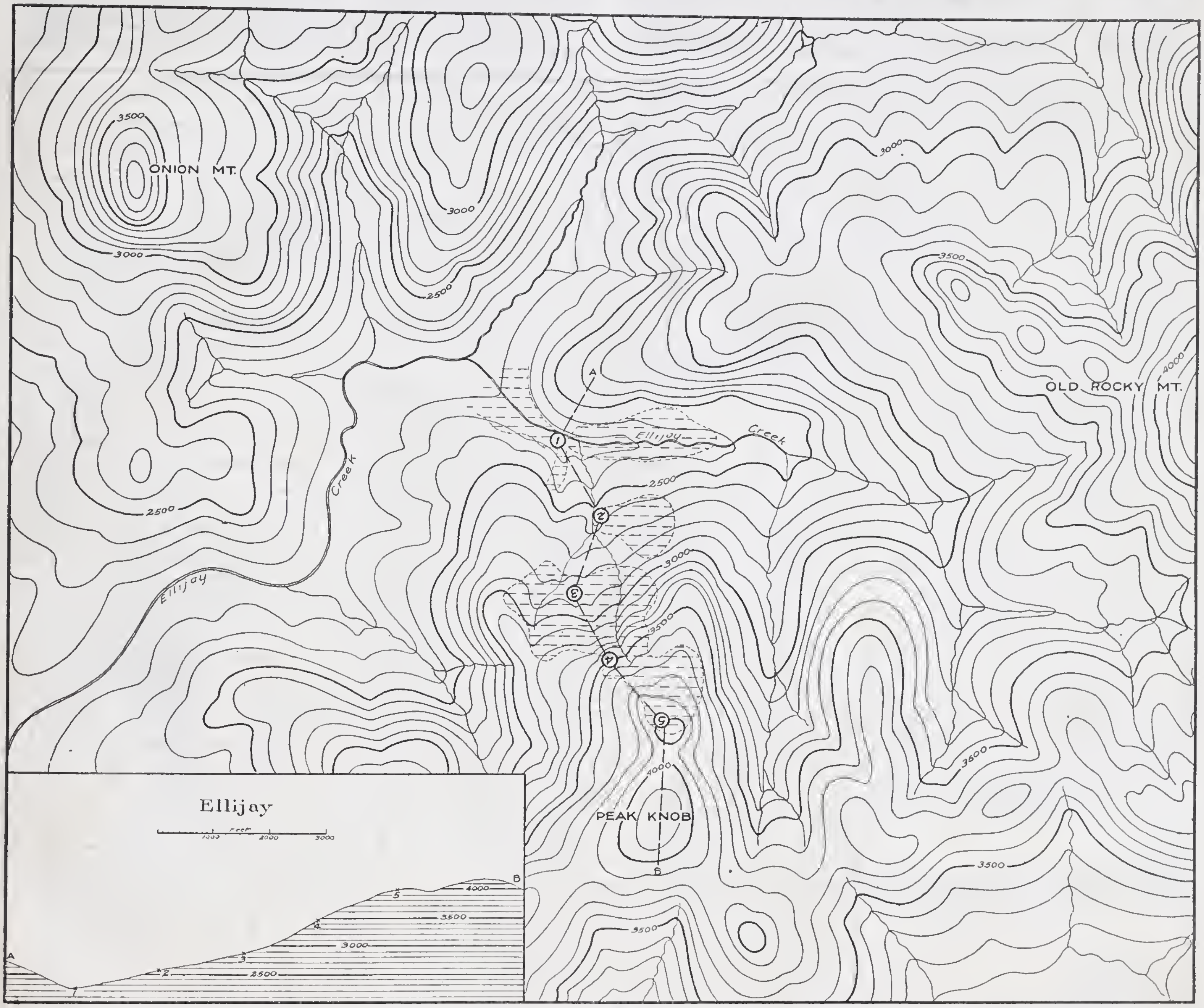

FIG. 3.—Ellijay, contour map and profile.

steep high slopes, more or less broken, while to the south, slope abrupt near the valley floor; orchard at some distance south of shelter on northerly slope broken and uneven with natural terraces here and there; valley narrow and trending in east-west direction, almost entirely inclosed by mountains. Station No. 2, in orchard, on rather steep northerly slope with ferns and weeds on all sides, 310 feet above station No. 1; timber to north, northwest, west and southwest; cleared land directly to east, northeast, and southeast, and for some distance to the south, about 500 feet. Station No. 3, the home station, 620 feet above dead, close by; abrupt slopes to the north and east. (See fig. 4, Peak Knob in the distance to the right.) Ellijay Creek, near which station No. 1 stands, flows in a westerly direction through a narrow valley, and the slope on the north side is broken up into spurs and hogbacks. (See fig. 5 for photograph taken from station No. 4, showing mountains and slopes on north side of Ellijay Creek.) For a vertical distance of 1,760 feet between stations Nos. 1 and 5 at Ellijay, there is a horizontal distance of about 5,100 feet, equivalent to an average grade of 19°. The grade on some portions of the slope is more than 30°.

HIGHLANDS.

T. G. Harbison, Observer.—Highlands is on an elevated plateau close to the Georgia border, and its group of five stations is on the property of the observer in two different orchards more than 2 miles apart, No. 1 and 2 being in the Satulah orchard on a southerly slope directly below Mount Satulah, and Nos. 3, 4, and 5 in the Waldheim orchard on the southeast slope of Dog Mountain. These stations have the highest elevation of all used in the research, station No. 5, near the summit of the Waldheim orchard slope, having an altitude of 4,075 feet. The place is near the southern end of the Blue Ridge. There are several mountain peaks in the vicinity, the more prominent being Satulah and Whiteside, with elevations of 4,560 and 4,930 feet, feet distant. Timber within 30 or 40 feet of shelter and between it and Mount Satulah, located to the northeast and north, which towers directly above and appears like an immense rock reaching an elevation of more than 1,000 feet above station No. 2. The grade from that station to the summit of the rock is 45°, while the average grade in the orchard itself is only 10° or 11°; timber to west is close by and reaches also a little to the south and is rather high. Station No. 3, the base station of the group in the Waldheim orchard, has an elevation of 3,675 feet above sea level; shelter in grass plot in a sink immediately below orchard; slope above not steep, except near the lower edge directly above station No. 3, and for a short distance above station No. 4. Station No. 3 near the bottom of a general east to southeast slope, surrounded by trees, except where the ground slopes upward

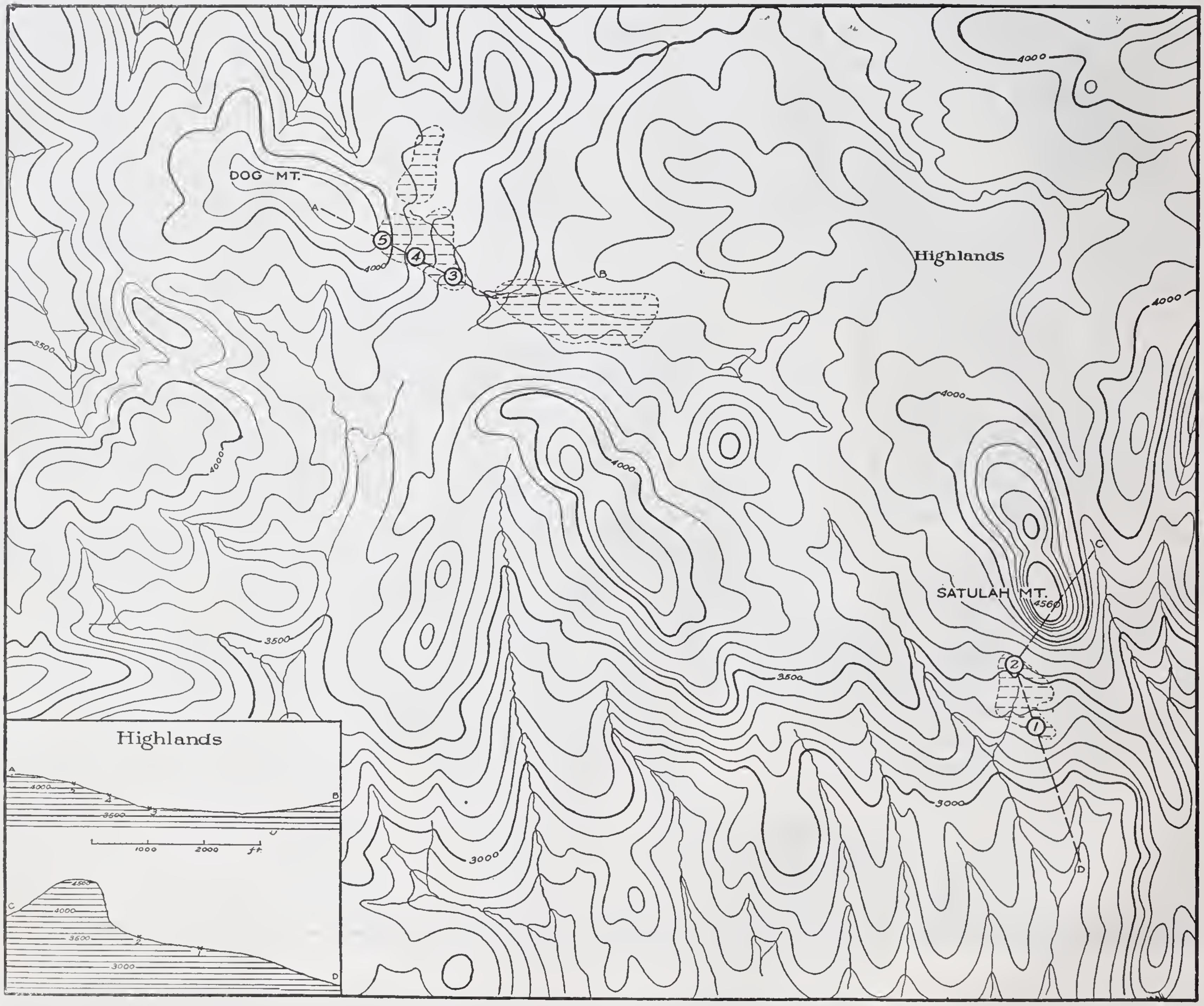

FIG. 6.—Highlands, contour map and profile.

respectively. Highlands is only a few miles northwest of Rock House or Horse Cove, where the largest amount of rainfall in the United States is recorded with the exception of the extreme north Pacific coast. (Fig. 7 shows the cooperative station at Rock House, the thermometer shelter being in the center of the picture.) Station No. 1, in the Satulah orchard, the home station, 3,350 feet above sea level, almost directly south of Mount Satulah and about 1,500 feet distant from its base. The ground slopes rapidly away from the shelter to the southeast and west. Slope rather moderate immediately to the north in orchard; in fact, slope in that direction does not become steep for more than 1,000 feet, but beyond that point toward Mount Satulah the grade is quite steep. Station No. 2, 200 feet above station No. 1, in a horizontal direction about 1,000 feet distant. Shelter located over a grassy plot with apple trees all around and only a few toward the orchard on the northwest side; no descent on any side of this depression, but land somewhat broken. The depression is a natural frost pocket. (Fig. 8 shows station No. 3, looking to the northwest toward orchard.) Station No. 4, 200 feet above station No. 3, on a southeast slope in orchard over sod covered with grass, weeds, and bushes in the midst of apple trees; slope at this point moderately steep and in an east-southeast direction. Station No. 5, 400 feet above station No. 3, in apple orchard 20 to 30 feet below upper limit; slope moderate near shelter and moderately steep most of the way down; shelter 150 to 120 feet below the summit of Dog Mountain. Timber above orchard to the west and northwest, also to the south, but not heavy, the closest timber being about 25 feet distant. Average grade between stations Nos. 3 and 5 is 16°, much greater than between stations Nos. 1 and 2 in the Satulah orchard.

BLANTYRE.

John E. Davidson, Observer.—A group of four stations on the State Farm at Blantyre, located in the valley of the French Broad River, which is rather wide at this point. The river falls here at the rate of only about 100 feet in 35 miles of meandering over the plateau. Base station, No. 1, close to the valley floor, 2,090 feet above sea level; the other three stations about a half-mile distant on the northwest slope of Little Fodderstack and separated from the base station by a gradual ascent partly timbered. Big Fodderstack, a few hundred southeast and a small hill to the north and northwest; shelter in lower edge of apple orchard. Above station No. 2 the grade rather steep and the side of the mountain terraced; the slope broken up considerably in various directions. The sag in which station No. 2 is located slopes gently from the southwest to the northeast; and this is apart from the general slope thence upward to summit of Little Fodderstack in a southeast to south direction. Station No. 3 in the midst of apple orchard, 150 feet above station No. 2, is about half way up Little Fodderstack. Shelter located on a hogback or ridge 50 or 60 feet broad running northwest down to station No. 2. Slope down, steep,

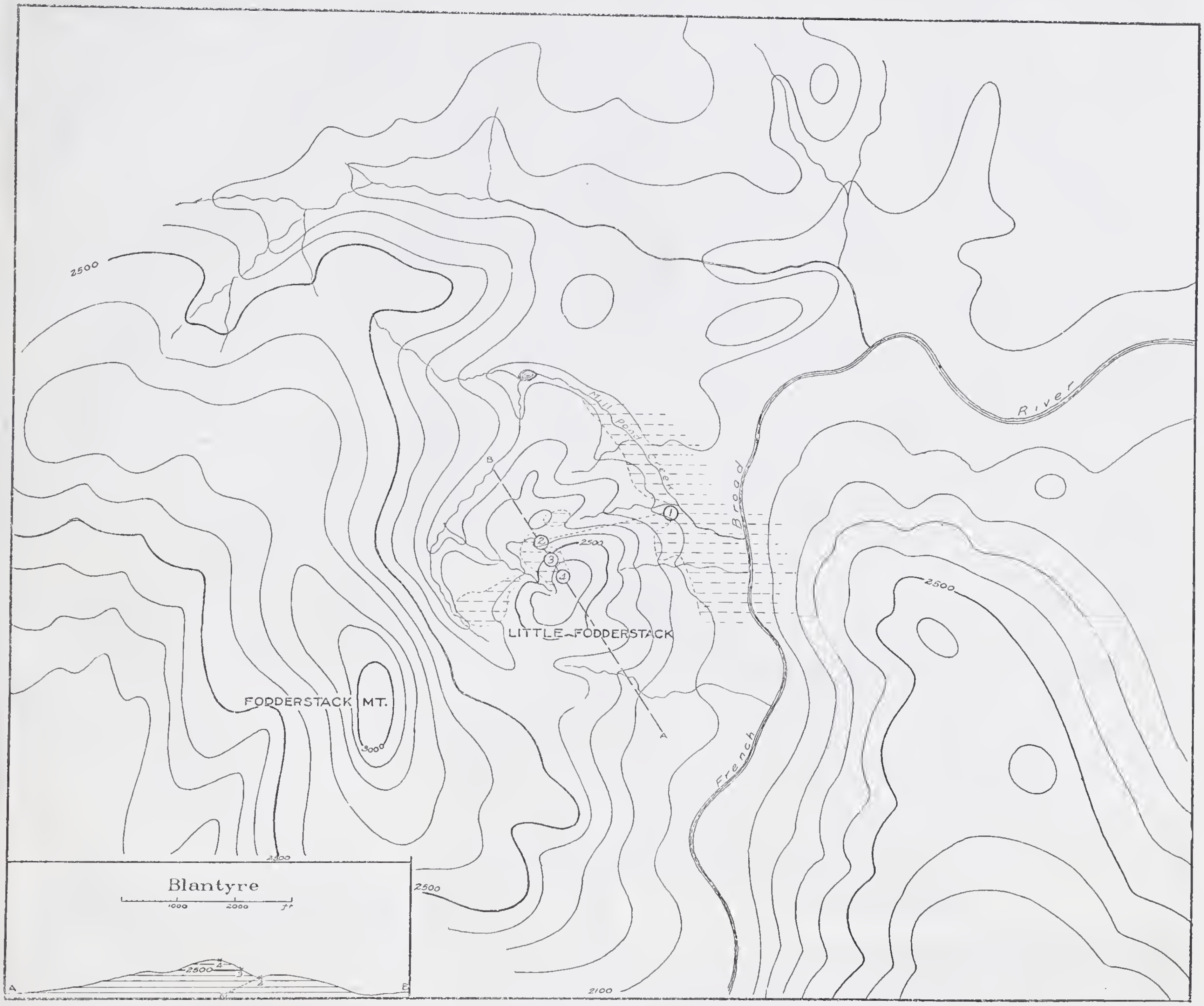

FIG. 9.—Blantyre, contour map and profile.

feet higher than Little Fodderstack, distant about a mile to the southwest, but no high mountains in the immediate vicinity. Nine or ten miles away are several high peaks, including Mount Pisgah, which stands to the northwest in the distance with a maximum height of 5,749 feet. Country in immediate vicinity of research stations rolling and broken. Station No. 1, home station (fig. 10), over a grass plot slightly above the bottom lands on one of several terraces 15 feet wide, with moderate slope; gentle slope upward in rear of shelter to the south and southwest only few degrees to base of Little Fodderstack; to the southeast of shelter a peach orchard in terraces about 30 feet distant from shelter. Station No. 2 (fig. 11), 300 feet higher than station No. 1, in a sag between Little Fodderstack to the 20 feet northwest of shelter, slope upward directly beyond shelter, more moderate. Station No. 4, 300 feet above station No. 2 and 600 feet above station No. 1; shelter on a hogback almost on summit of Little Fodderstack, but the ground a few feet higher to the south, southeast, and east; 20 to 40 feet south and southeast of shelter it slopes almost generally in all directions. Sparse timber southwest, south, southeast, and east of shelter 20 to 40 feet distant; clear view at station No. 4 at sunrise and sunset; shelter located over grass and just beyond upper limit of orchard. Average grade between stations Nos. 2 and 4 about 22°, only a few slopes, such as Altapass, Ellijay, Globe, and the China orchard at Blowing Rock having sections any steeper. Fig. 12 gives good view of orchard including stations Nos. 3 and 4.

HENDERSONVILLE.

S. McCarson, Observer.—The group of four stations at Hendersonville located 3 miles to west of the city, the base station in a meadow and the other three in the apple orchard of Capt. M. C. Toms on the moderate slope of Echo Mountain, or Hickory Hill, some distance southwest of the base station. This group of stations is only about 7 miles distant from Blantyre on the other side of the French Broad River. Jump Off Mountain, the most prominent point in the vicinity, with an elevation of 3,141 feet, lies distant less than a mile west of Echo Mountain, which respectively; brush and scrub pine to west 40 feet and timber to west about 300 feet distant. Station No. 2 (fig. 15) over thin grass on sandy soil 450 feet above station No. 1, and 3,500 feet distant in a horizontal direction west by south, at the bottom of apple orchard; timber, not heavy, surrounds shelter from southwest to northeast by way of southeast, at varying distances, forming a semicircle. Station No. 3 (fig. 16) in midst of apple orchard, soil covered with grass, 600 feet above station No. 1, on a uniform northeast to east slope from the summit; slope at No. 3 more easterly, continuing in that direction for descent of from 40 to 50 feet, then a little gap between two small knolls to the

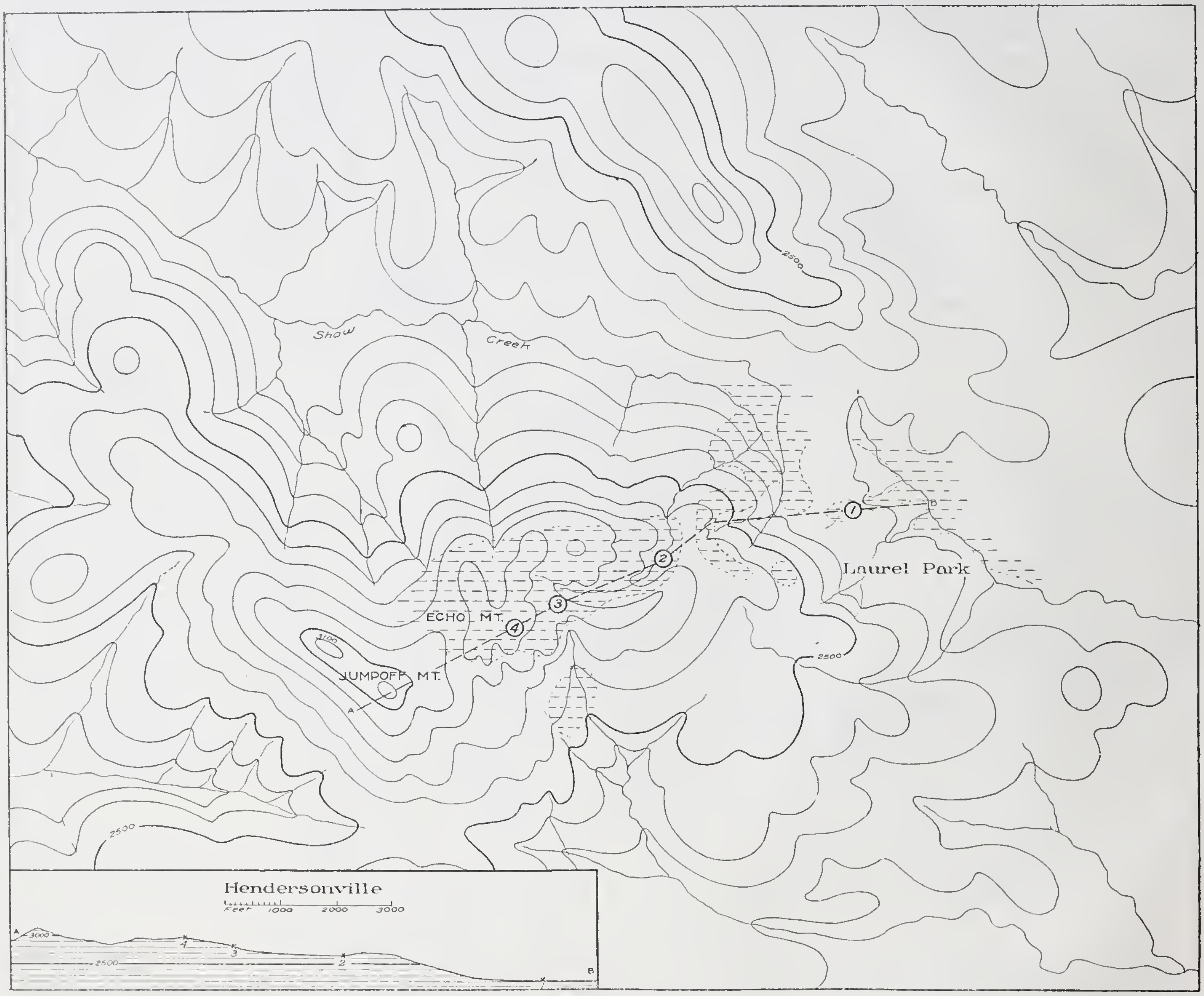

Fig. 13.—Hendersonville, contour map and profile.

has an elevation of 2,950 feet, there being a sag between the two knobs. There is also a small knob, Mount Davis, a short distance to the north and of about the same elevation as Echo Mountain. Below these mountains there is a more or less gradual downward slope in practically all directions to an extensive plain which reaches for many miles, mountains in the distance surrounding. Station No. 1 (fig. 14), 2,200 feet above sea level on a bench some distance removed from the valley floor, on a grassy plot with a very slight declination to the east; shelter surrounded by timber except at opening to east through a narrow gap; slight slopes upward to north and south, on both of which timber is located, the timber being 30 to 50 feet north and south of shelter, north and to the south. Station No. 4, the home station, 750 feet above station No. 1, in apple orchard on the knoll called Hickory Hill or Echo Mountain. The shelter distant 10 feet or more from small apple trees, with clover, grass, and weeds covering the soil. The general slope at Hendersonville is more gradual than at any of the other places, except possibly Gorge and Transon, the slope being sharp at only a few points. The average grade between stations Nos. 1 and 4 is only 7° and that between stations Nos. 1 and 2 about the same. However, the grade between station Nos. 3 and 4 is somewhat steeper. There is here a wider expanse of surrounding plains than in the vicinity of any other station, except possibly Wilkesboro and Mount Airy.

ASHEVILLE.

Chas. V. Joyner, Observer.—The five stations on Mr. Chas. H. Webb's property, about 4 miles northeast of the city of Asheville, on a bench above the valley of the French Broad River, which is approximately the center of the North Carolina mountain region. Mr. Webb's property lies on the north and south slopes of Bull Cove Branch (fig. 18, photograph taken from north slope in the orchard looking down the valley toward the city of Asheville). Station No. 1, the home station, over grass at an elevation of 2,445 feet above sea level, in a sag between northerly and southerly slopes. Stations Nos. 2 and 3 on rough broken soil in apple orchard (fig. 19) on a northerly slope of Bull Mountain, 155 feet and 380 feet, respectively, above station No. 1. Stations Nos. 2a and 3a on the opposite southerly slope (fig. 20) at the same elevations, respectively, as stations Nos. 2 and 3. Station No. 3, only a few feet distant from heavy timber to the south, west, and east within 300 feet of the top of a spur reaching westward from the peak of Bull Mountain, which towers a thousand feet above, but station No. 3a, in a clearing surrounded by timber on the opposite slope, is within about 100 feet of the summit of the ridge, projecting across from Rice Knob. The southerly slope is much steeper than the northerly one. While stations Nos. 3 and 3a are each 380 feet above station No. 1, the horizontal distance on the south slope is only 1,200 feet, while it is 2,000 feet on the north slope. The north slope is broken up into ridges and hogbacks, but the south slope is more regular. The southerly slope has a grade of nearly 18°, while the opposite northerly slope has a grade of only 10½°. It is rather level immediately in the vicinity of shelter at No. 2 on northerly slope in the midst of the orchard, but quite steep at point opposite on southerly slope where No. 2a is located in open field over short grass (fig. 20). The shelter at No. 3, because of its location on a northerly slope and proximity to timber, is shut off from practically all sunshine.

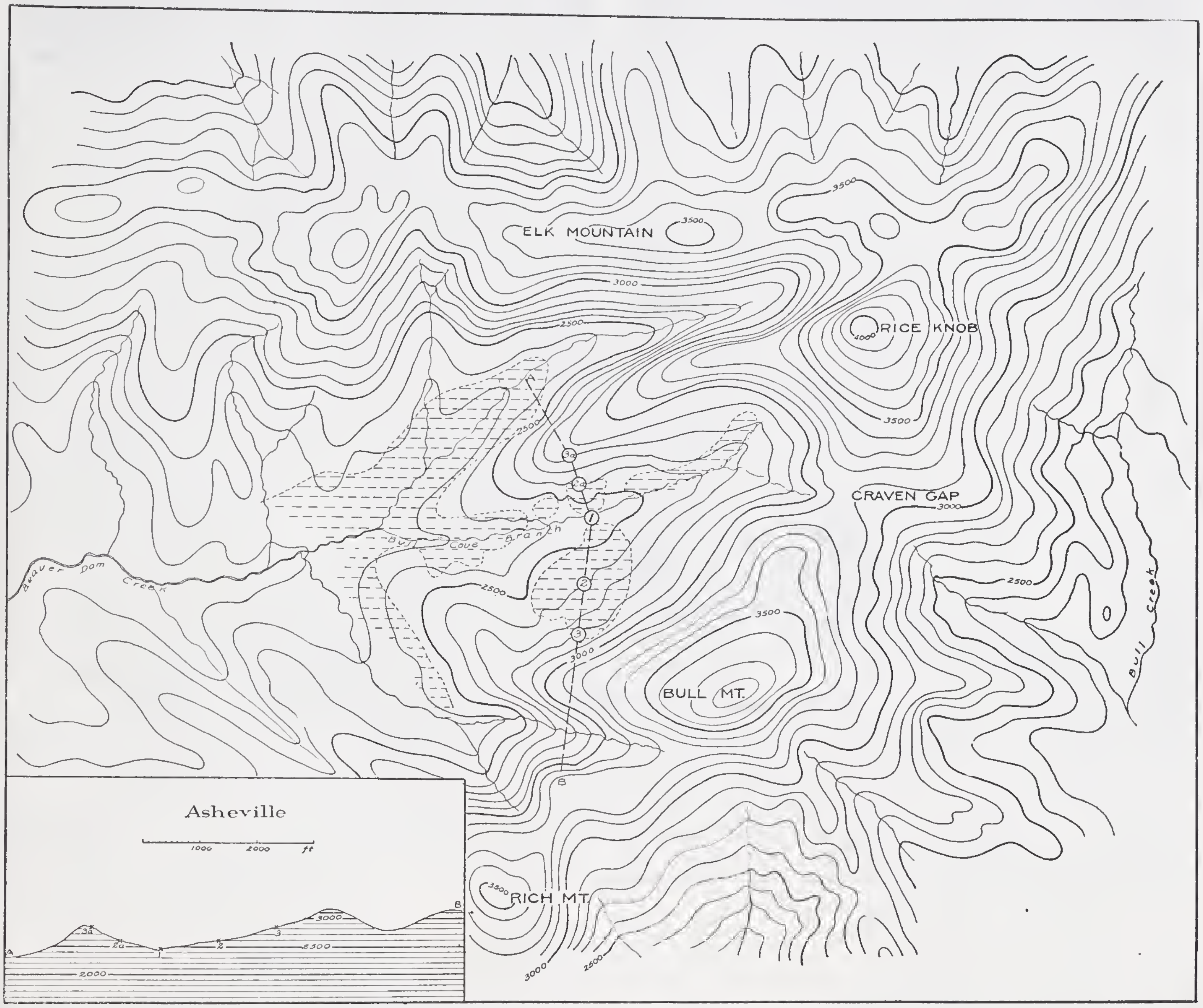

Fig. 17.—Asheville, contour map and profile.

TRYON.

W. T. Lindsey, Observer.—The stations at Tryon, four in number, located about 2 miles to the northwest of the village; station No. 1 (fig. 22), on the valley floor of the Pacolet River, at an elevation of 950 feet above sea level, the lowest of the experimental stations used in this research; stations Nos. 2 and 3 in the vineyard of the observer, on the southeast slope of Warrior Mountain, and station No. 4 higher up on the slope, with an elevation of 1,100 feet above station No. 1 and within 400 feet of the summit (figs. 22 and 23). There are several other mountains in the immediate vicinity in the same range, the station No. 2 is rather steep to the east and southeast, but almost level as station No. 1 is approached; shelter over broken ground with grass and weeds, especially to the north; timber covers most of the slope between stations Nos. 1 and 2, also some timber to the east 50 to 75 feet; vineyard practically surrounded by timber, terraced and fairly steep, but not so steep as immediately below or above. Station No. 3 (fig. 24), 570 feet above station No. 1, on southeast slope about 50 feet above upper rim of vineyard; in a small apple orchard over grass, weeds and rocks; rather a steep slope above to station No. 4, with brush and high timber about 100 to 150 feet to north, northwest, west, and southwest, half encircling station. Station No. 4, 1,100 feet above

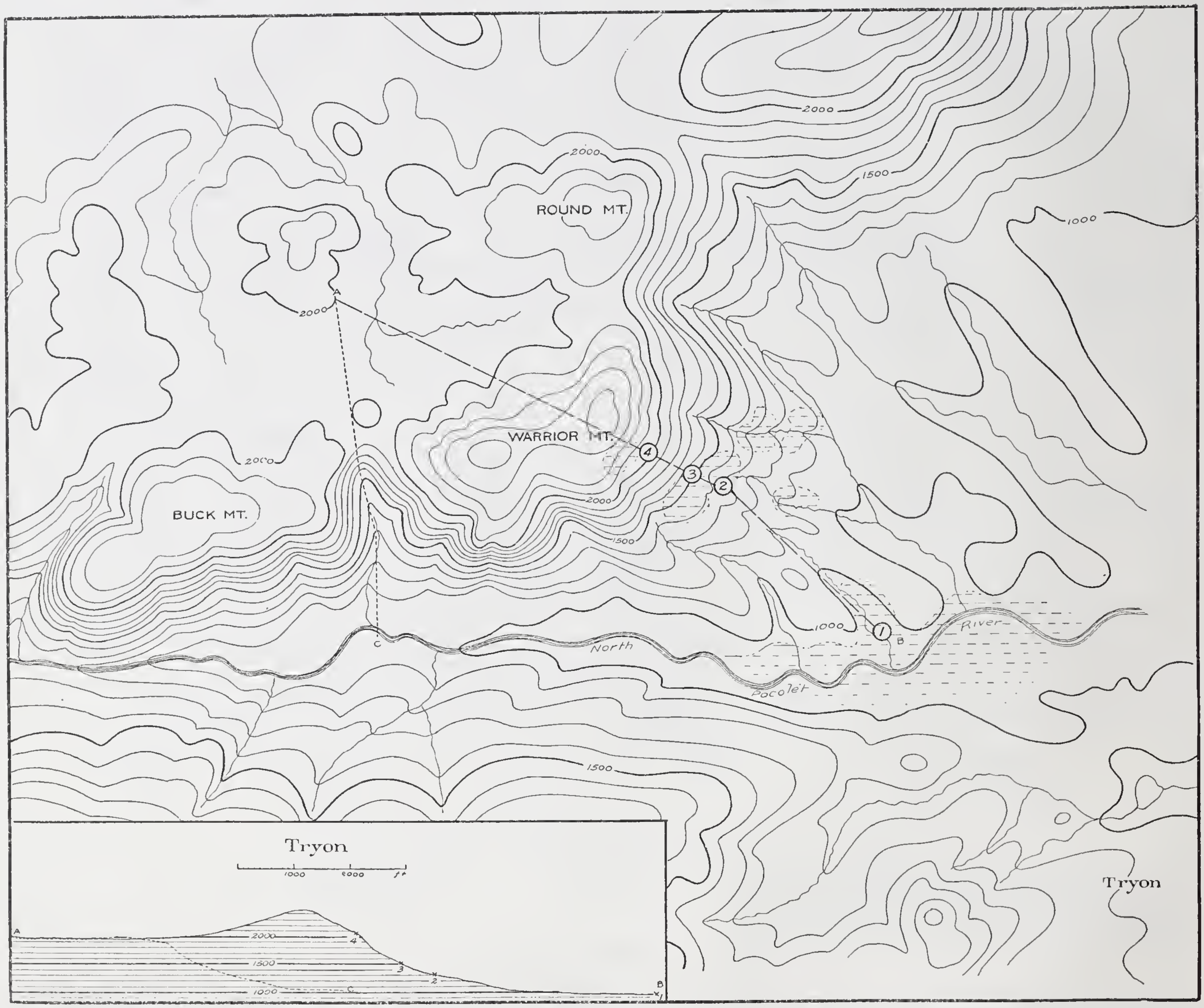

FIG. 21.—Tryon, contour map and profile.

most prominent being Tryon Mountain to the northeast, with an elevation of 3,231 feet, while that of Warrior is only 2,465 feet. Then there is Round Mountain, almost midway between Warrior and Tryon. Across the Pacolet valley is Melrose Mountain (see fig. 24), but not near enough nor of sufficient mass to serve effectively as an opposing slope to Warrior Mountain where the research stations were located. Station No. 1, located on the rather wide valley floor of the Pacolet River running in east-west direction, is well situated for the experimental work, being at the foot of Warrior Mountain, on a grass covered plot on ground practically level. Shelter at the home station, No. 2, on lower edge of vineyard, on southeast slope 380 feet above station No. 1, the horizontal distance being 4,000 feet. The slope below station No. 1, is on southeast slope on edge of cliff with sharp drop of several hundred feet to station No. 3; is over grass and weeds in small cleared space; timber and brush within 10 to 20 feet on all sides except south and southwest, where sheer drop occurs. From station No. 4 the ground slopes upward rather steep in places to the summit of mountain more than 400 feet above. Slope is heavily timbered above and below station No. 4. The slope, as a whole, from station No. 1 to station No. 4 has an average grade of about 11½°, but immediately above the valley floor, between stations Nos. 1 and 2, the grade is very gentle, while between stations Nos. 2 and 4 the grade is quite steep, especially above station No. 3. The average grade between stations Nos. 2 and 4 is about 26°.

CANE RIVER.

Hiram A. Profitt, Observer.—Cane River is located on the northwest side of the Black Mountains, and the orchard stations, four in number, are about 2 miles west of the village, on the property of the observer; the base station in a level plot having an elevation of 2,650 feet above sea level and somewhat above the valley floor of McElroy Creek, a branch of Cane River. The summit station is high up on a knob above a steep timbered slope 1,100 feet above the base and about northerly slope; heavy timber on steep upslope to the south, southwest, and southeast of shelter; some timber also to the east and west more distant; hills also in those directions 500 or 600 feet away; shelter located over grass-covered surface. Station No. 3, 400 feet above station No. 1, on northerly slope moderately steep; shelter in upper portion of apple orchard near base of mountain in a cove-like inclosure, with grass-covered surface; heavy timber to east, southeast, south, southwest, and west. Sun shut off by timber during early morning and late afternoon hours for the greater portion of the year; steep

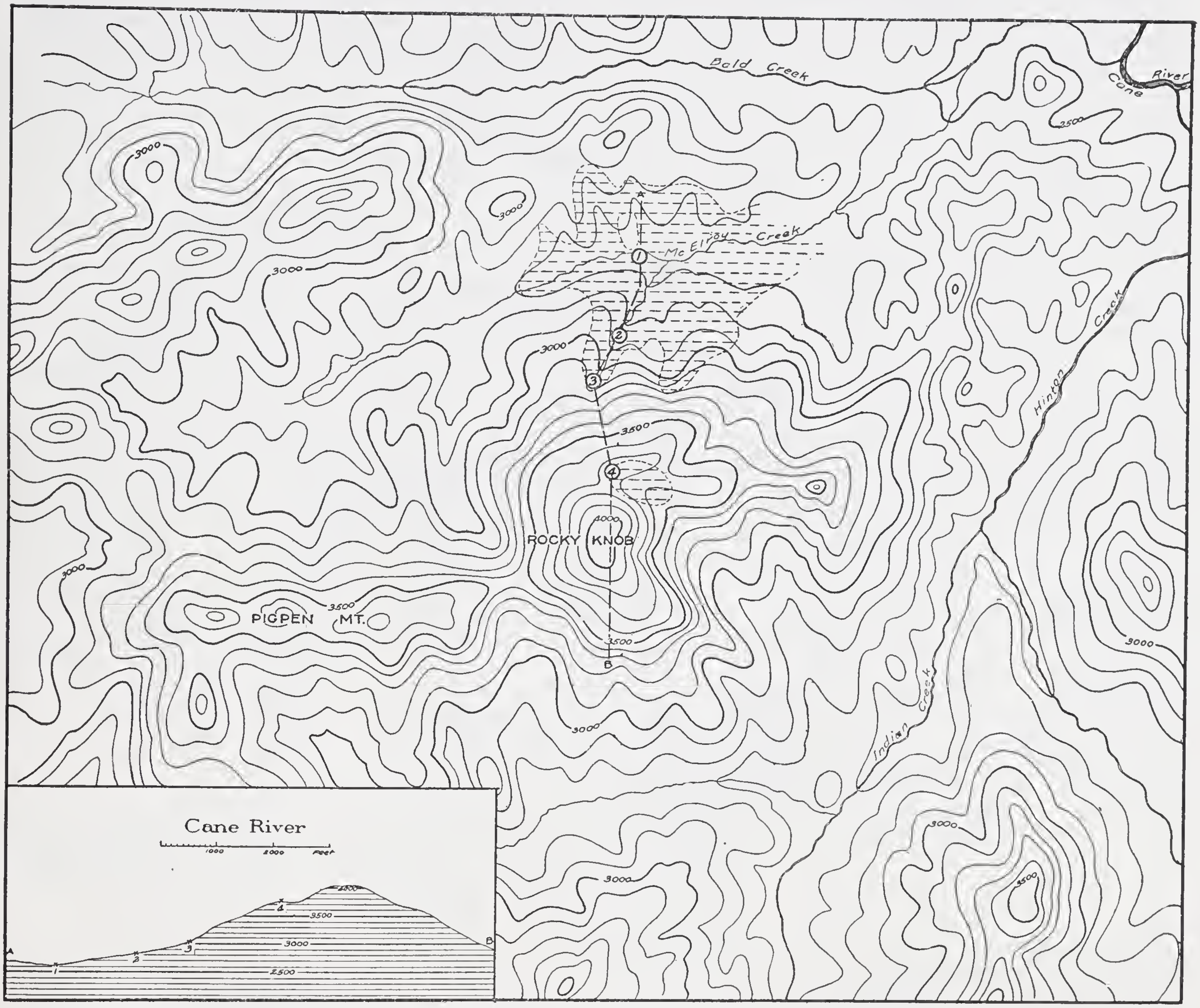

FIG. 25.—Cane River, contour map and profile.

1,000 feet distant from Rocky Knob, which stands 250 feet higher. The country throughout this section is rolling and broken and most picturesque, with knobs of various elevations here and there. The two knobs, with generally sharp profile and small mass in proportion to their elevation, are isolated peaks which rise considerably above surrounding peaks within a radius of several miles. Station No. 1, the home station, on a nearly level plot, which was covered with grass in 1913 and 1914; in 1915 and 1916 planted in corn; slope generally from north to south, but very slight at station No. 1. Station No. 2, 190 feet above station No. 1, in apple orchard on moderate upward slope to south and also where timber is located to east; a sharp ascending slope covered with heavy timber from station No. 3 to station No. 4. Station No. 4, 1,100 feet above station No. 1, on knob with steep slope downward from the shelter in every direction, except toward Rocky Knob to south, there being a sag between the two knobs; small timber 10 feet north and west of station No. 4, also 15 to 20 feet northeast; heavy timber beyond in practically all directions. The slope, as a whole, from station No. 1 to station No. 4 has an average grade of 16°, being quite gentle below station No. 3 and steep above, the incline above station No. 3 being 24°.

ALTAPASS.

R. F. Brewer, Observer.—Altapass is on the main range of the Blue Ridge Mountains, the village itself being on the divide directly north of McKinney Gap, with the Black Mountains, including Mount Mitchell, Clingmans Peak, and Celo Mountain standing up at great heights to the west, Grandfather Mountain and Brown Mountain to the east, and smaller knobs in between. The southeasterly slope containing the experimental stations is steep, while the slope on the other side of the Blue Ridge to the north and northwest is gentle. Five stations here timber and hills to east and west 200 feet or so. Station No. 3, home station, 500 feet above station No. 1, shelter in peach and apple orchard on sharp southeasterly slope; slope broken into ridges and hogbacks. Station No. 4 (fig. 28), 750 feet above station No. 1; shelter in apple orchard with small trees in vicinity; on steep southeasterly slope; soil badly gullied and worn away here by flood in the summer of 1916. Station No. 5 (fig. 29), 1,000 feet above station No. 1, on summit of ridge 200 feet wide and extending in a northeast-southwest direction and nearly level for a mile or so; shelter in midst of small trees over

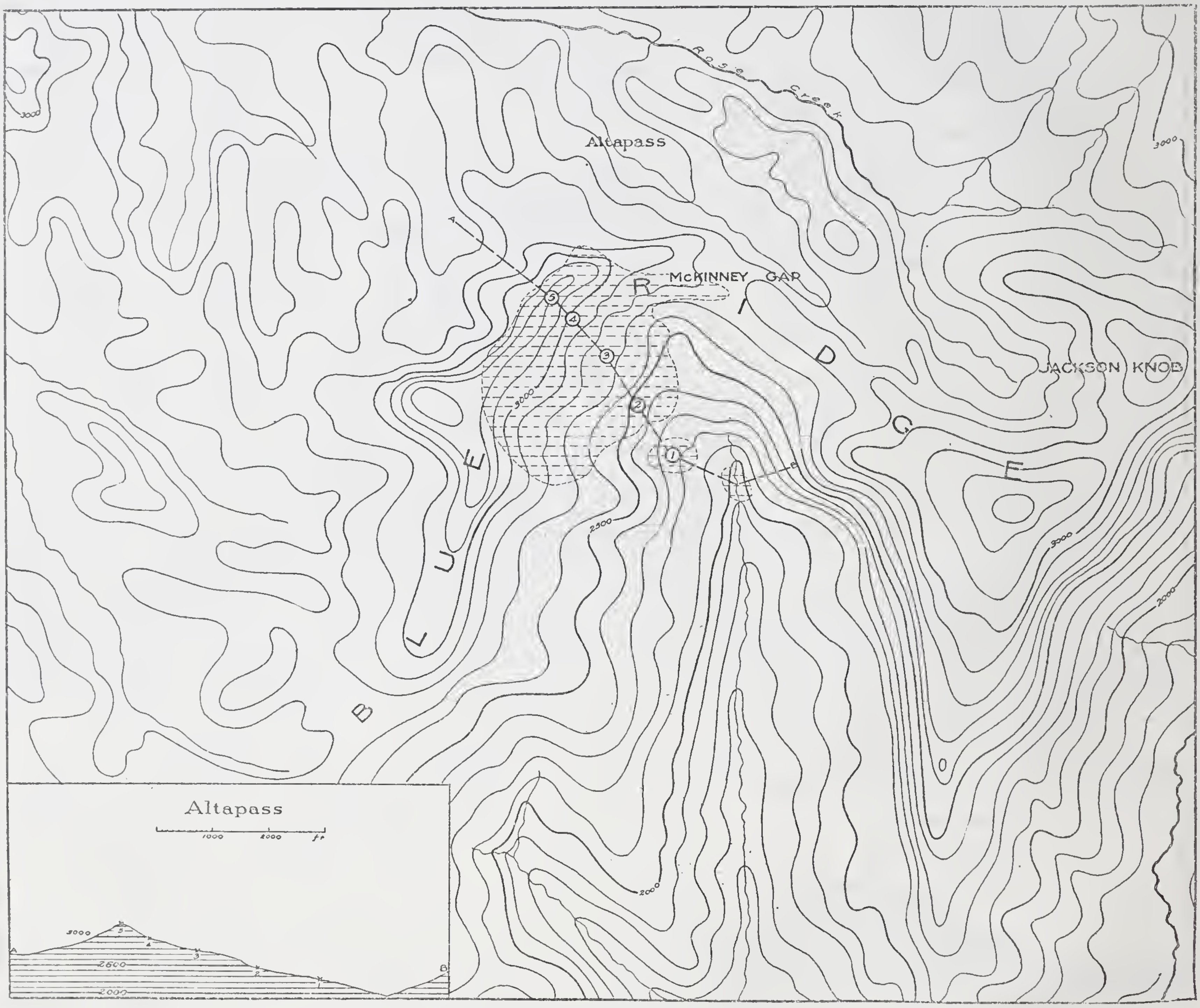

FIG. 26.—Altapass, contour map and profile.

are in the orchard of the Holston Corporation, the base station, No. 1, being 2,230 feet above sea level, with the others each 250 feet above its lower neighbor. While the summit station is directly on the main ridge, No. 1 is really on the slope, as the descent below continues 730 feet down to the valley floor at a place called North Cove, two miles distant from station No. 1. Station No. 1 is a small level plot in cornfield and surrounded by dense vegetation; timber and hills to west, northwest, and southwest close by; also to east but much farther away; hills to the north. Station No. 2 (fig. 27), 250 feet above station No. 1, in small level plot in cornfield in midst of steady southeasterly slope; grass and weeds, in marked contrast to the comparatively bare soil at the stations lower down on the slope, as shown in figure 28, where the vegetal cover is thin because of the steepness. The slope becomes steadily steeper from station No. 1 to summit and is especially steep between stations Nos. 4 and 5. The average grade of entire slope from station No. 1 to station No. 5 is about 16° and is probably more regular and uniform than any other long slope, except Ellijay, which has an average grade of 19°. The entire Altapass slope, including that below station No. 1, is about 1,730 feet in height, and the Ellijay slope is 1,760 feet.

BLOWING ROCK.

E. G. Underdown, Observer.—The village of Blowing Rock is located to the east of Grandfather Mountain (fig. 31) on the plateau flush with the crest of the Blue Ridge, running parallel there to the Tennessee boundary line and distant from it about 10 miles. The plateau here, as well as at Highlands, close to the Georgia boundary, averages more than 3,500 feet in elevation. To the west and south of the village there is a sharp descent to the valley of the Johns River, and beyond as far as the eye can see are towering mountains. On the plateau itself are several knobs, of which the two principal ones lie to the north of the village, Pine Ridge and Flat Top, with elevations of 4,400 feet and 4,590

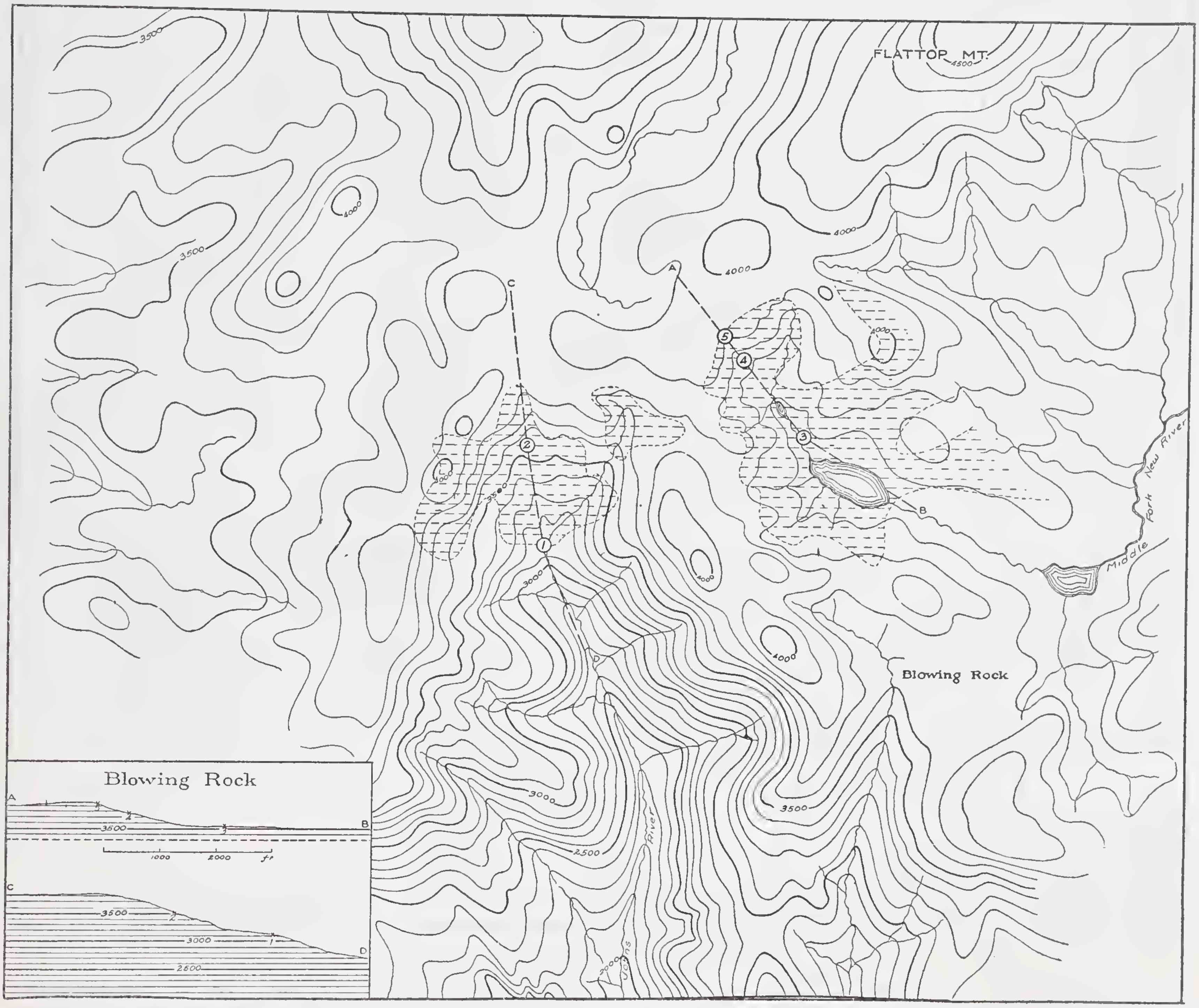

FIG. 30.—Blowing Rock, contour map and profile.

feet, respectively. The experimental stations are five in number, divided into two groups, three in the Flat Top orchard and two in the China orchard, both apple orchards, and owned by Mrs. Abram Cohn, located, respectively, from 1 to 2 miles north and northwest of the village, and distant from each other about one-half mile. In these two and the Green Park orchard, another property of the Cohn family in the vicinity, are approximately 40,000 apple trees, the three combined being probably the largest property of the kind in the East. The China orchard, containing stations Nos. 1 and 2, is on a steep and narrow southerly slope which drains into the Johns River. Station No. 1, elevation 3,130 feet above sea level; shelter over sod on southerly slope; timber on sharp slopes to east, southeast, southwest, and west from 30 to 50 feet from shelter. The slope continues downward from the China orchard to a ravine far below. Station No. 2, in rough grassy plot, 450 feet above No. 1, on rather steep southerly slope, broken up into ridges and hogbacks, so that while the general slope is south and southeast the local slopes in the orchard vary. The orchard extends upward from station No. 2, with a rather uniform steepness. The average slope in this orchard is about 15°. The slope extends 320 feet above No. 2 and 1,130 feet below No. 1, in all a vertical height of about 1,800 feet, even greater than those at Altapass and Ellijay, but for purposes of the discussion this slope will not be classed with the other long slopes because of lack of suitable observation stations. The Flat Top orchard (figs. 32 and 33) is shaped much like an amphitheater which gradually slopes down from the upper rim to a lake or large pond at the base. The basin is mostly inclosed, and the descent at the outlet is gradual. The orchard is broken up into moderate ridges and saddles, but generally all slopes lead toward the lake, while beyond hills and slopes extend in different directions with small gaps between the hills. Station No. 3 in the Flat Top orchard has an elevation of 3,580 feet, the same as No. 2 in the China orchard, and is on the valley floor, near a large pond or lake, shown in figure 33, on an almost level surface over rather thick grass. The ground at station No. 3 slopes gradually upward to the northwest to a smaller pond, a steep slope beginning immediately beyond and rising in a northwesterly direction to stations Nos. 4 and 5. There are sharp slopes on both sides of station No. 3 to the east and northeast and the west and northwest, respectively, the slope on the east side being distant about 25 feet, while that on the west is about 100 feet. Station No. 4, 175 feet above station No. 3, over grass on moderate slope in midst of apple trees; the slopes curve around more

or less brokenly tending on one side downward toward the east and on the other toward the west or southwest. Station No. 5, 350 feet above station No. 3, the home station; located on upper rim of orchard just below roadway near the residence of owner. Shelter is over long grass. From this station the orchard stretches down in all directions, except to the northeast, north, and northwest. The average slope from station No. 3 to station No. 5 in the Flat Top orchard is less than 9°, compared with the slope of 15° between Nos. 1 and 2 in the China orchard. There is a large extent of surface area in the vicinity of No. 5 approximately at the same level, and the surroundings are much unlike the knobs on which several of the summit research stations were located. No. 3 is the valley floor station for the Flat Top group at Blowing Rock, just as No. 3 at Highlands is the valley floor station of the Waldheim group.

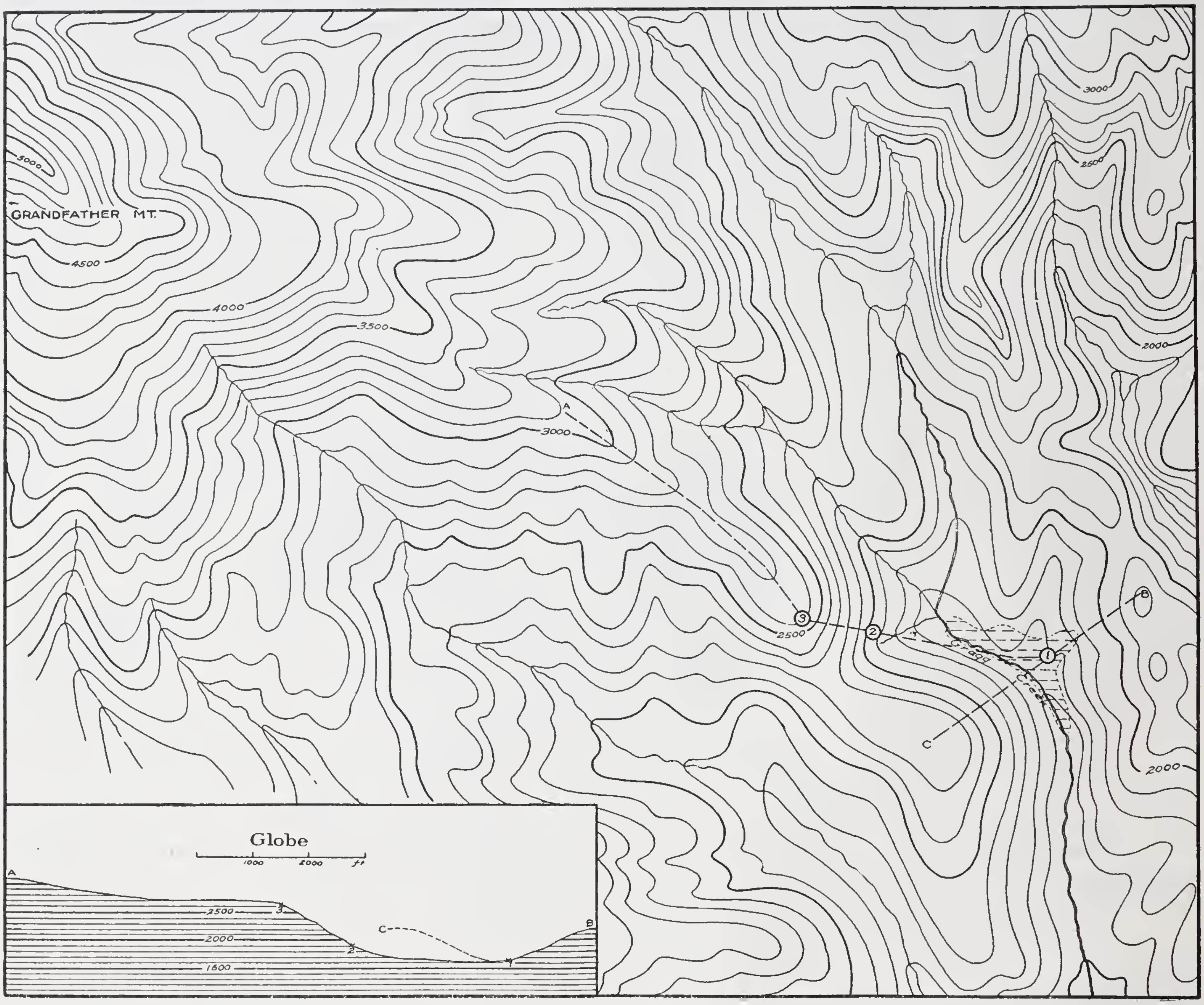

FIG. 35.—Globe, contour map and profile.

GLOBE.

Julius L. Gragg, Observer.—Globe, with its group of three stations, is located in the midst of mountains, Grandfather Mountain to the northwest and Brown Mountain to the southwest. The Summit station is on the southeasterly slope of a spur of Grandfather, called Snake Den Mountain. The valley of Gragg Fork, in which the base station is located, is here narrow and winding and reaches generally in a northwest-southeast direction; but below, the direction is more southerly, draining the northern portion of the eastern slope of Grandfather Mountain. The slopes are steep on both sides of the valley, except in the lower levels of the mountain, where the slope is gradual. Station No. 1, the home station, 1,625 feet above sea level, on a level grass plot across Gragg Fork from the base of mountain, shade trees in yard about 25 feet distant from shelter to the north; south and east is timber about 300 feet distant and to the west about 600 feet. Station No. 2, 300 feet above station No. 1, in small orchard on east to southeast slope; shelter in small patch of cleared land surrounded by timber 200 to 300 feet distant on side of mountain on moderate slope, but steep above and below; sunshine cut off early in afternoon, especially in late fall and winter. Station No. 3. on summit of ridge 1,000 feet above station No. 1 on Snake Den Mountain; shelter in clearing surrounded by brush and timber about 20 feet distant in all directions; grade steep up the mountain from station No. 2 to station No. 3. Timber covers practically the entire mountain; peaks all around. The entire slope from station No. 1 to station No. 3 averages about 13°, but that from station No. 2 to station No. 3 averages more than twice this—28°.

GORGE.

Wm. A. Tolbert, Observer.—Gorge is located at the base of Brown Mountain and the stations, five in number, reach along the Black Bee Branch up the slope to the summit of Little Chestnut Knob, the slope downward being in a general northeasterly direction. The main peak of Brown Mountain is distant about a half mile to the southeast with a sag between. The region is quite mountainous, but there are no peaks of great height in the immediate vicinity. The main chain of the Blue Ridge lies to the north, northwest, and west of Brown Mountain. Station No. 1, the home station, 1,400 feet above sea level, in the valley floor of Wilson Creek, is in a gap close to Black Bee Creek farther away. Although the general slope on this side of the mountain is northeasterly, the ground is so broken at No. 3 the slope turns there to the southerly, thus forming a cove or pocket partly inclosed, with sunshine cut off in the afternoon. Station No. 4 (old), 840 feet above No. 1, in an abandoned orchard on the north slope on a hogback which slopes off gently to the east and west; in the midst of brush, apple and other small trees, and 20 to 30 feet away from larger timber, but none very large; station in operation in 1913 and 1914 only. Station No. 4 (new), 840 feet above No. 1, in operation in 1915 and 1916, located on a moderate northerly slope in clearing over thin grass, although the general slope is northeasterly. Station is surrounded by trees of different heights at distances varying from 60 to 125 feet; small brush all

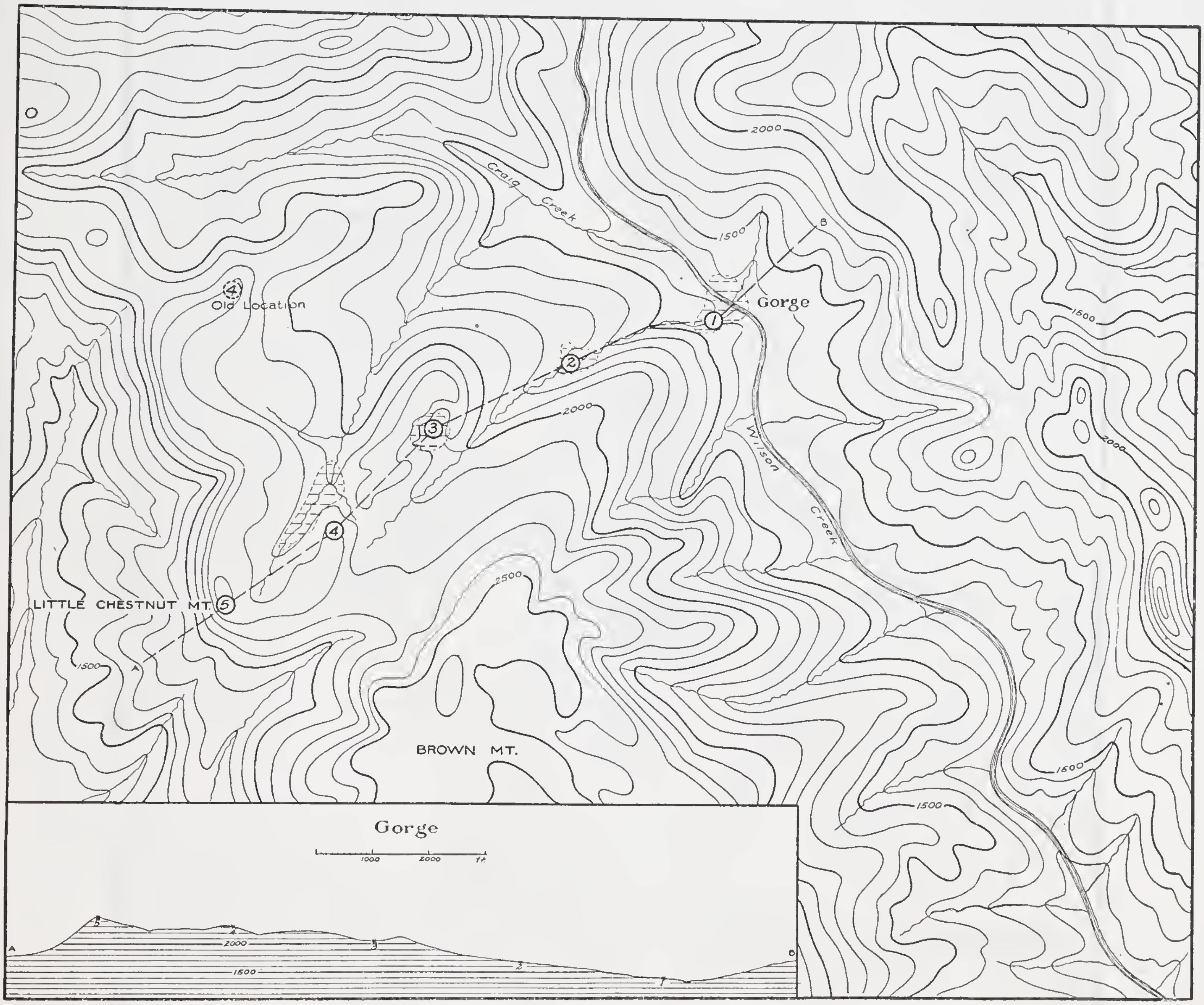

Fig. 36.—Gorge, contour map and profile.

and a short distance west of Wilson Creek, into which Black Bee empties. The gap runs from west to east between hills for 500 feet. The station, over comparatively bare soil and on rather level plot with brush close at hand, is surrounded by hills and mountains, with timber. Station No. 2, in Bagley orchard, 290 feet above station No. 1, on northeasterly slope, about 50 feet east of Black Bee Creek. The valley here runs from southwest down to northeast and is surrounded by hills, this location partaking of base station conditions. Surface under shelter rather bare; slope up from No. 1 to No. 2 gentle, as is, in fact, almost the entire slope. Station No. 3, 615 feet above No. 1 in Chestnut Hollow Cove, on moderate north to south slope; timber is rather thin and 100 to 300 feet distant in all directions. Hills and mountains are around. This station is distant about 4,500 feet in a horizontal direction from the old No. 4, and was substituted for it at the close of 1914 because of the inconvenience in reaching the old location. Station No. 5, 1,040 feet above station No. 1; shelter on Chestnut Knob in midst of brush; sparse timber distant 20 to 30 feet in all directions; knob slopes off on all sides, there being a level space of about 30 feet square on the top where shelter stands. The timber around station No. 5 does not cast nearly as much shade as at station No. 4. For a long slope, Gorge is the most gradual of all employed in this research, the horizontal distance between the base and the summit stations being about 2 miles for a vertical distance of 1,040 feet. The entire slope from base to summit averages only 6°.

TRANSON.

Sidney M. Transon, Observer.—Transon is in the extreme northern portion of the Carolina Blue Ridge region at a considerable elevation, the lowest of the experimental stations in the group of four stations being 2,970 feet above sea level. The country in the immediate vicinity is rolling and broken with peaks here and there in the distance although not so mountainous as the sections farther south. The stations are on the property of the observer. The base station, No. 1, 2,970 feet above sea level; the home station, on a level grass plot in a cove on the westerly slope about 300 feet above the valley floor of Peak Creek; no timber in the immediate vicinity. Station No. 2, over grass, also on the west slope 150 feet higher up, the ground being rather flat where the shelter stands and the general slope gradual. Station No. 3, 300 feet above station No. 1, has much the same exposure as No. 2, over grass; rather flat surface with general westerly gradual slope; some timber about 300 feet to the south. Station No. 4, 450 feet above station No. 1, in a flat grassy plot on a small knob. Almost the entire slope is gradual, except immediately below station No. 4. Stations Nos. 1, 2, and 3, are in the same straight line, and for a vertical difference of 300 feet between stations Nos. 1 and 3 there is a horizontal distance of about 3100 feet. While the general slope is westerly, it is not a steady decline from station No. 4 to the base, there being some small secondary hills or humps on the way. Above, as well as below, station No. 3, for instance, the ground descends, and also at station No. 2, but to a lesser extent. The entire slope between stations Nos. 1 and 4 averages about 8°.

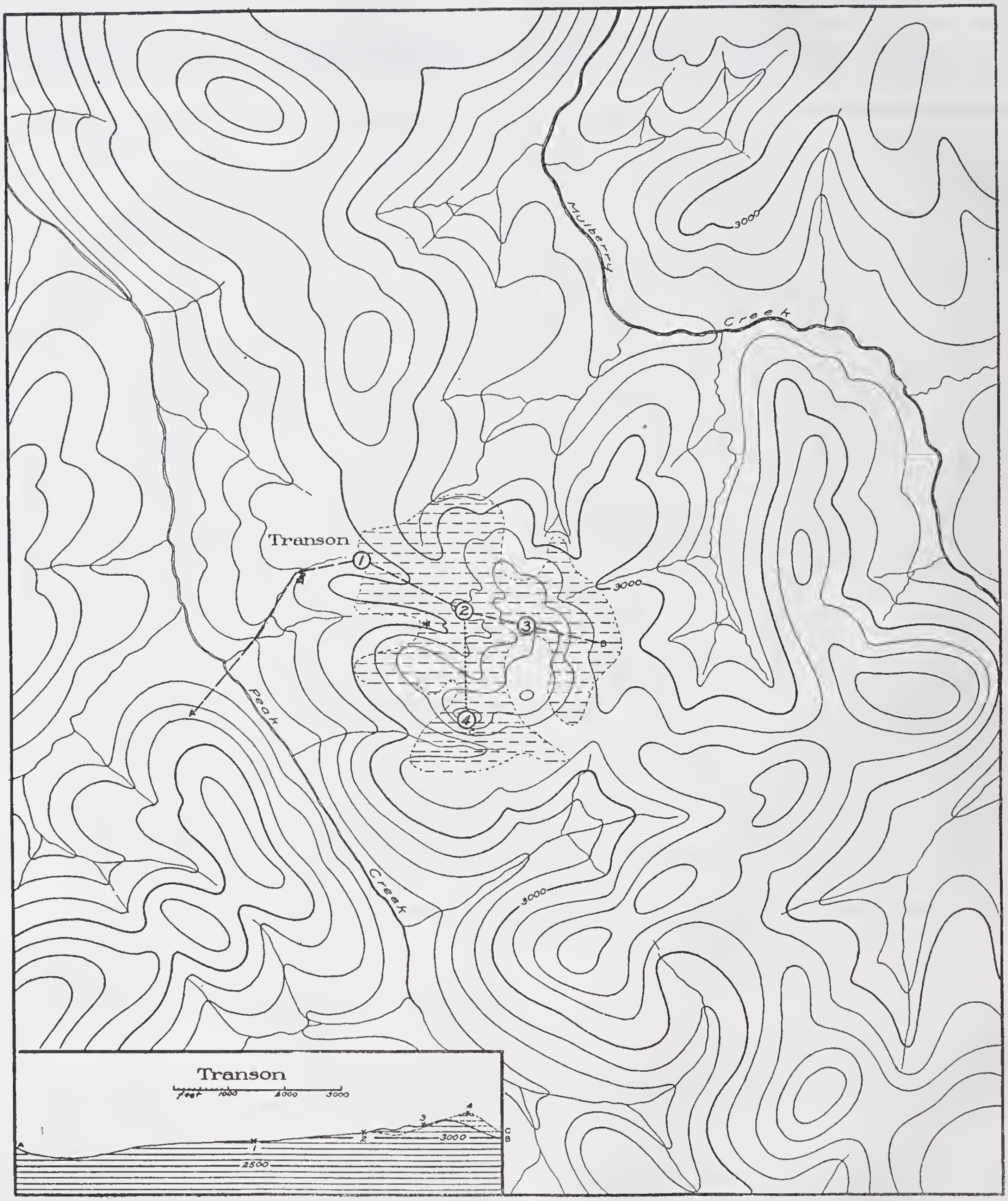

FIG. 37.—Transon, contour map and profile.

WILKESBORO.

John Johnston, Observer.—Wilkesboro is considerbly east of the Blue Ridge, in the valley of the Yadkin to the north of the Brushy Mountains. The principal town there is now called North Wilkesboro, but the experimental stations, four in number, on the north slope of the Brushy Mountains, are nearer to the old town of Wilkesboro. The stations are in the orchard of Dr. Charles A. Willis and lie on a moderate northerly in apple orchard across road just below station No. 3, on moderate slope with grass covered soil. Station No. 3, 350 feet above station No. 1, on northerly slope, on knob in orchard over weedy surface; sag between it and station No. 4; ground flat around shelter for 100 to 200 feet or more then slopes off all directions. Station No. 4, 430 feet above station No. 1, on grass covered soil in apple orchard on rather level ridge, extending north and south and about 130 feet below summit of the

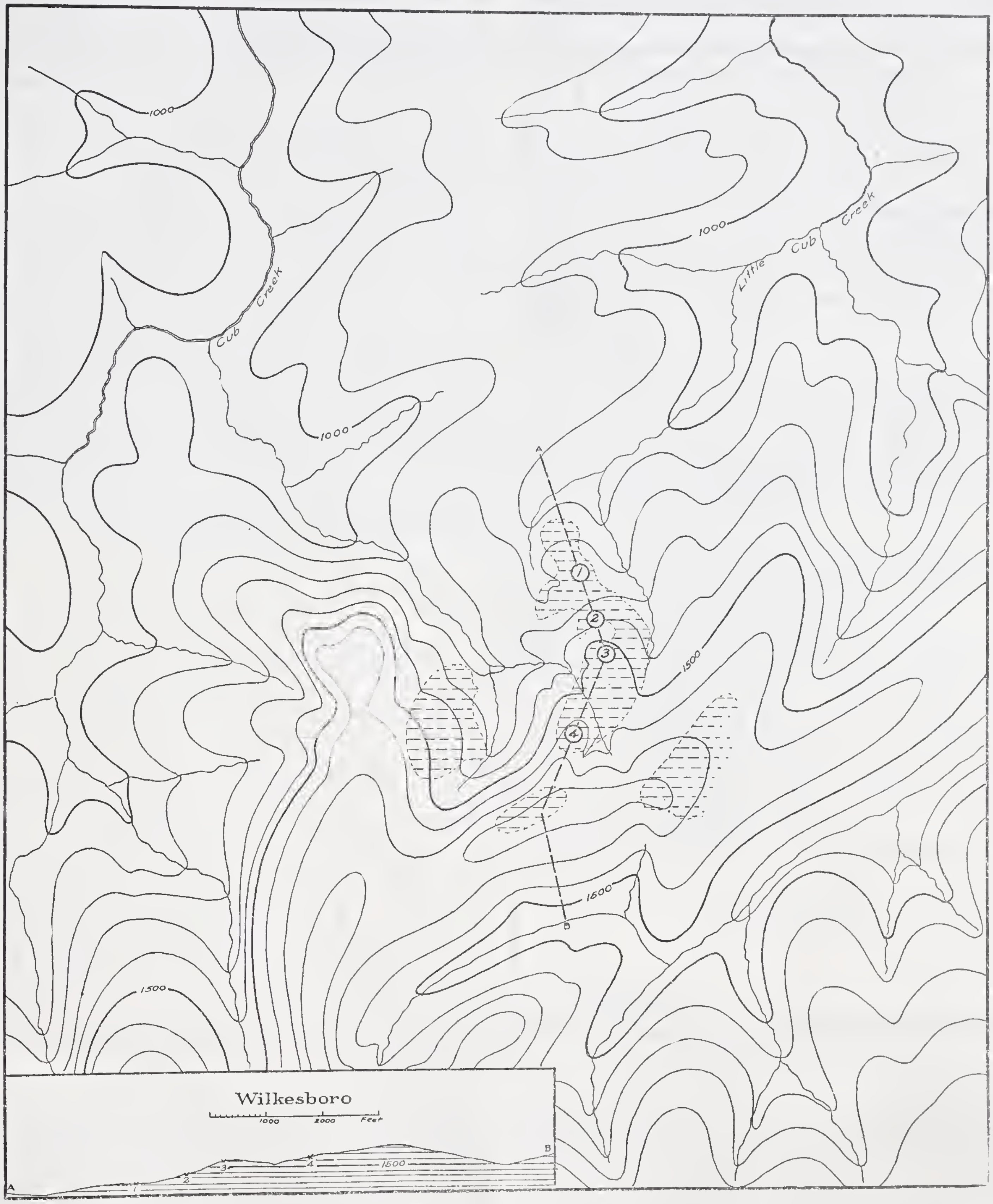

FIG. 38.—Wilkesboro, contour map and profile.

slope at a point about midway between Nos. 15 and 38, as shown on the relief map. Station No. 1, with an elevation of 1,240 feet above sea level, about 300 feet above the valley floor of the Yadkin, on a bench a few hundred feet in extent on a northerly slope. The ground in vicinity of station No. 1 is rather uneven and almost bare of grass and about 400 feet distant to the north descends to the valley floor below; some timber to the west of shelter, 1,000 feet, and to the east, 120 feet. Station No. 2, on notherly slope, 150 feet above station No. 1; shelter Brushies, which lie to the south about 1,000 feet or more across a sag running west to east. A short distance to the north is a sharp slope downward; directly east and west of shelter is a slope downward to broken country, and to the south 200 to 300 feet there is considerable timber. Below to north, northeast, and northwest lies a broad valley or level plain extending 20 to 30 miles to the Blue Ridge beyond. The differences in elevation between these stations are slight; the grade between Nos. 1 and 3 is 13° and between Nos. 1 and 4, 8°.

MOUNT AIRY.

J. A. Sparger, Observer.—Mount Airy, close to the Virginia border, is of course, even farther than Wilkesboro from the main mountain region, and in the vicinity there are only a few spurs or peaks, and these are of rather slight elevation. The experimental stations here, four in number, are on the property of the Sparger Orchard Co., about 6 miles east of the city of Mount Airy, on Slate Mountain, station No. 1 at the base, stations Nos. 2 and 3 on the western and eastern slopes, directions is rather flat, but the land becomes rolling as the mountain is approached. Station No. 2, in orchard in cultivated area, 160 feet above station No. 1, on fairly steep westerly slope, with timber 150 feet upslope; the land on this slope somewhat broken to the north and south; slope to the south rather moderate, but steep to north from a point 30 feet from shelter. Station No. 3, on easterly slope, with the same elevation as station No. 2; slope more gradual as compared with the westerly slope; not in orchard but on rough weedy ground, and between it and the summit is a belt of timber. Station No. 4

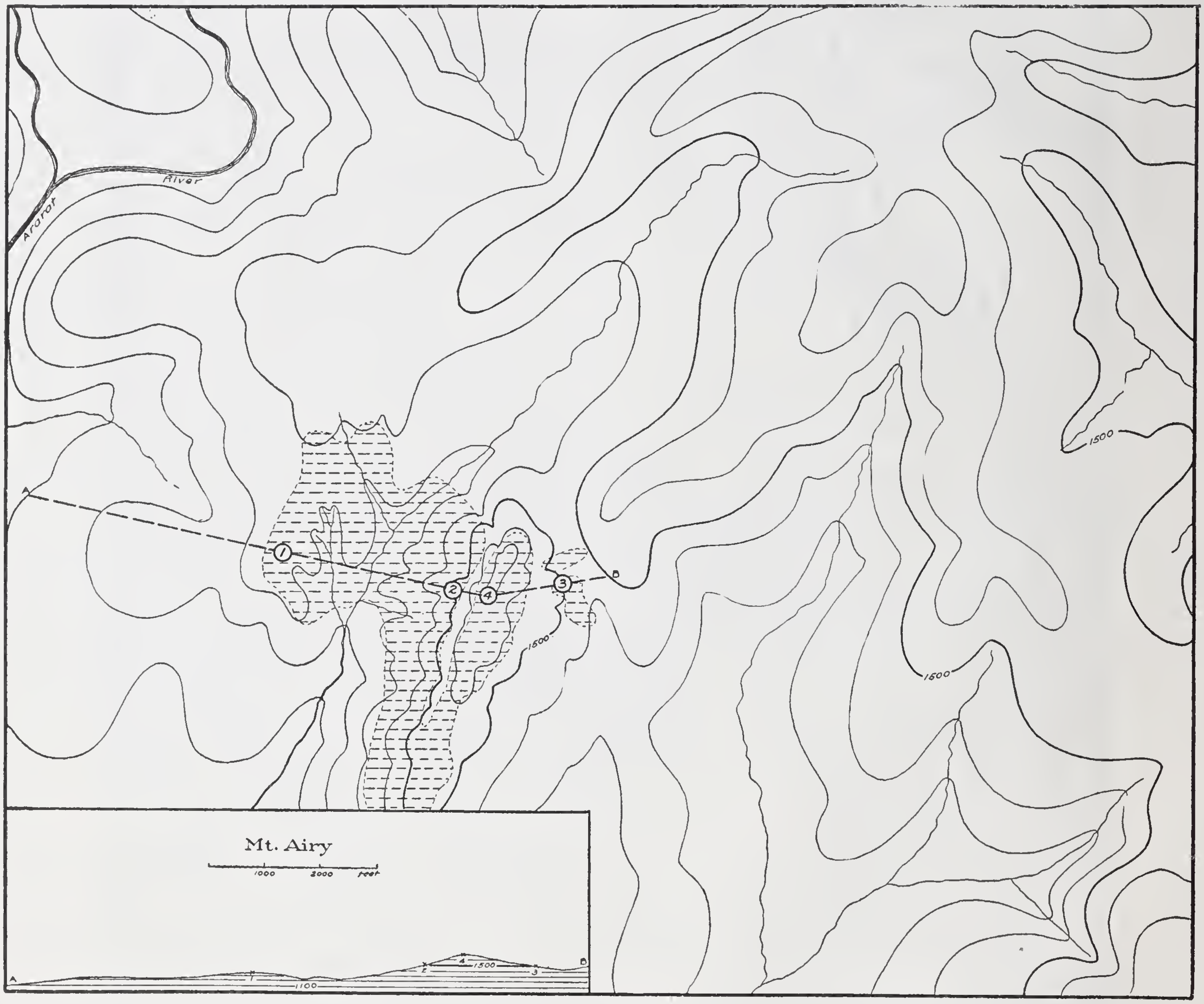

FIG. 39.—Mt. Airy, contour map and profile.

respectively, and station No. 4 at the summit. Slate Mountain overlooks the city of Mount Airy, which stands on a broad plain to the west. Distant 10 to 20 miles farther west are the Sorrytown Mountains, a branch of the Blue Ridge, extending in a southwesterly direction and across the Yadkin to the southwest, 30 miles or more away are the Brushy Mountains. To the east is a broken country for 15 to 30 miles with several spurs of varying heights. Station No. 1 (fig. 40), the home station, 1,340 feet above sea level, on a level plot of grass, somewhat distant from the base of the mountain on which the orchard is located. The country near station No. 1 for several hundred feet in all (fig. 41), in orchard 360 feet above station No. 1, is on the summit of the ridge 200 feet across and almost level, with slight slopes leading thence directly toward the west and east. The ridge runs from northeast to southwest 1 mile, undulating somewhat brokenly; a portion of the ridge to the northeast about a quarter of a mile away is about 30 feet higher than shelter No. 4. Horizontal distance between station No. 3 and the summit is nearly three times as great as the distance between the summit and station No. 2. The average grade on the westerly slope between stations Nos. 2 and 4 is 16°, as compared with the average grade on the easterly slope between stations Nos. 3 and 4 of 10°.

ARRANGEMENT OF TABLES.

It is necessary to limit the publication of the tabular matter to the smallest size consistent with an understanding of the problems under consideration. If only a few slopes were under investigation, it might have been possible to publish the data in greater detail, as there would then have been a relatively small number of stations involved; but in this case we shall have to be content for the most part with summarized tables, except when it becomes necessary in expounding certain theories to give daily and hourly values.

The average maximum, average minimum, absolute maximum, and absolute minimum temperature, and the absolute and average range and mean temperature will be discussed in the order named, and then will follow special chapters on inversion and norm conditions, frosts, lengths of the growing season, and a few supplementary studies bearing upon the situation. Graphs have been employed to emphasize special features, and it is thought that those, together with the tables, will be considered sufficiently comprehensive.

Physical explanation of local variation in temperature.—Before taking up the discussion of the observational data or dealing with the question of temperature and circulation within the valleys, it appears highly important to present in a connected form a somewhat comprehensive explanation of the causes of the conditions which the observations disclose.

It must be recognized that the progressive changes of temperature from hour to hour and from day to day at any one locality result from a great many causes, but our present problem is chiefly concerned with changes going on between daytime and nighttime in mountain valleys at times when the atmosphere is clear and little or nor wind prevails, especially at night. Even in the daytime on these occasions the motions of the atmosphere are more or less dominated by local influences rather than the general cyclonic or anticyclonic circulation and changes of temperature are then due primarily to solar insolation in the daytime and radiation at night.

It is well known that atmospheric absorption and radiation, especially when the atmosphere is relatively dry or free from clouds, are very small. Important changes of temperature are then brought about chiefly by contact with the earth's surface, which is warm or cold according to circumstances. It is important to recognize that on this account we must regard the walls and floors of valleys as the primary heating agency of the atmosphere during the daylight hours, and, conversely, during the nighttime these same walls and floors are the primary cooling agencies by reason of the active loss of temperature by the surface cover and vegation of the walls, due to nocturnal radiation.

The processes by which the heating in the daytime and the cooling which occurs at nighttime communicate heat to the atmosphere or receive heat from the atmosphere are the phenomena which we will try to make clear in the interpretation of such observational data as have been collected in this study.

TEMPERATURE.

MAXIMUM TEMPERATURE.

In the discussion of average maximum temperature Table 1 is supplemented by Tables 1a, 1b, 1c, and 1d.

The avearge maximum readings contained in these tables are deduced from the maxima observed during the daytime only, instead of the 24-hour maxima, just as later in the discussion of the mean minimum temperature night minima only are used. This plan has been adopted in order to make possible comparisons of day conditions, on the one hand, and of night conditions, on the other, and the influence of maxima that occurred in the nighttime or minima in the daytime will thus be eliminated.

The maxima in the mountain region vary considerably because of difference in latitude, elevation above sea level, character of the weather, whether cloudy or sunshiny, shade from neighboring timber, hills, or mountains, the direction and degree of inclination of the slope, the seasonal variation of the sun, the character and amount of vegetal cover, and the absolute and relative humidity of the air.

TABLE 1.—*Monthly and annual average maximum temperatures, 1913–1916.*

[The differences between the averages at the base station and those of the respective slopes may be seen by simple inspection.]

Principal and slope stations elevation above mean sea level of base station (feet).	Height of slope station above base (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Altapass:														
No. 1, base station, elevation 2, 230	....	[1] 47.4	[1] 47.3	[1] 50.7	65.7	75.0	79.3	82.0	81.2	74.9	68.2	58.6	46.8	64.3
No. 2, SE	250	[1] 46.6	[1] 46.4	[1] 49.6	64.8	74.6	79.0	81.1	80.2	74.8	67.9	57.6	46.2	64.1
No. 3, SE	500	[1] 44.9	[1] 44.7	[1] 48.0	63.3	73.2	77.4	79.2	78.4	72.7	65.4	55.8	44.6	62.3
No. 4, SE	750	[1] 43.9	[1] 43.4	[1] 47.4	62.0	71.8	76.1	78.1	77.6	71.3	64.7	55.2	43.1	61.2
No. 5, summit	1,000	[1] 43.1	[1] 42.7	[1] 46.6	61.5	70.8	75.3	77.7	76.9	71.2	63.8	54.6	43.0	60.6
Asheville:														
No. 1, base station, elevation 2,445	....	50.8	48.2	52.2	64.8	75.2	79.5	81.9	81.5	76.2	68.2	59.0	47.6	65.4
No. 2, N	155	49.4	46.7	51.2	64.0	74.8	78.8	81.1	[1] 80.2	[1] 74.8	66.1	56.9	46.0	64.2
No. 2a, S	155	50.1	47.7	51.5	63.9	74.0	78.2	80.4	80.2	75.3	67.2	58.2	47.3	64.5
No. 3, N	380	47.0	44.9	49.6	63.0	72.8	75.9	78.0	76.8	70.4	62.4	53.8	43.6	61.5
No. 3a, S	380	51.0	48.8	52.9	66.3	75.6	79.2	81.2	80.3	74.8	67.8	60.6	48.3	65.6
Blantyre:														
No. 1, base station, elevation 2,090	....	52.5	51.2	55.8	68.2	78.0	82.0	83.8	82.5	76.4	68.7	60.2	48.2	67.3
No. 2, NW	300	50.8	49.3	54.3	67.7	77.8	81.4	82.9	81.5	75.4	68.2	59.5	47.4	66.4
No. 3, NW	450	50.7	49.2	52.4	67.1	77.3	80.8	82.4	81.1	74.8	68.3	59.7	47.4	66.1
No. 4, NW	600	51.3	51.0	54.6	68.9	77.9	81.6	83.0	82.3	76.7	69.5	60.8	48.0	67.2
Blowing Rock:														
No. 1, base station, elevation 3,130	....	44.5	42.5	46.4	59.0	69.8	74.4	76.8	75.6	69.9	62.4	52.9	42.0	59.7
No. 2, S	450	44.0	42.5	46.1	59.0	69.2	74.2	76.1	74.4	69.3	61.8	53.0	42.3	59.4
No. 3, SE	450	42.8	41.2	44.7	58.2	68.2	73.2	75.1	73.8	68.0	61.2	51.8	41.3	58.3
No. 4, SE	625	43.5	41.8	45.1	57.8	68.2	73.4	75.8	74.6	68.9	61.4	52.5	42.2	58.8
No. 5, SE	800	43.0	40.6	44.8	57.8	67.7	73.0	75.4	74.2	68.3	60.8	51.6	41.3	58.2
Bryson:														
No. 1, base station, elevation 1,800	....	[2] 52.2	[1] 51.3	[1] 54.1	69.0	79.2	83.5	85.6	84.9	79.8	71.4	[1] 61.4	[1] 48.3	68.4
No. 2, N	385	[2] 50.6	[1] 51.1	[1] 54.1	68.9	79.4	82.8	84.8	84.2	79.2	70.4	[1] 59.8	[1] 46.4	67.6
No. 2a, S	385	[2] 52.3	[1] 52.2	[1] 55.1	69.8	79.7	82.9	84.7	83.8	79.0	71.4	[1] 61.6	[1] 48.2	68.4
No. 3, summit	570	[2] 51.1	[1] 52.1	[1] 55.9	72.7	81.6	84.1	84.9	84.0	78.6	70.1	[1] 60.2	[1] 46.3	68.5
Cane River:														
No. 1, base station, elevation 2,650	....	[1] 47.9	[1] 46.0	[1] 48.5	63.6	74.1	78.5	81.3	80.7	75.1	66.9	57.2	45.7	63.8
No. 2, N	190	[1] 46.9	[1] 45.5	[1] 48.2	63.3	73.9	78.4	80.6	79.7	73.8	66.0	56.9	45.1	63.2
No. 3, NE	400	[1] 43.2	[1] 42.6	[1] 46.7	62.8	73.5	77.4	79.2	77.6	70.8	61.9	52.0	41.4	60.8
No. 4, summit	1,100	[1] 44.1	[1] 42.9	[1] 46.1	62.6	74.6	77.2	79.0	77.4	70.7	62.8	54.4	42.9	61.2
Ellijay:														
No. 1, base station, elevation 2,240	....	[1] 51.4	[1] 51.0	[1] 53.6	68.1	78.1	81.8	83.8	83.1	78.2	70.3	61.3	49.8	67.5
No. 2, N	310	[1] 50.2	[1] 50.2	[1] 52.9	67.1	77.1	80.8	82.9	81.8	77.2	68.9	60.0	48.6	66.5
No. 3, N	620	[1] 49.1	[1] 48.6	[1] 51.3	64.9	75.0	79.0	81.0	80.0	74.6	67.4	58.6	47.7	64.8
No. 4, N	1,240	[1] 45.0	[1] 45.1	[1] 48.4	63.5	73.6	76.8	79.0	78.2	72.5	64.6	[1] 55.1	44.1	62.2
No. 5, summit	1,760	[2] 45.8	[2] 46.0	[1] 48.2	[1] 63.0	[1] 72.7	[1] 75.3	[1] 77.0	[1] 76.8	[1] 72.1	[1] 64.4	[1] 55.0	[1] 44.1	[1] 61.7
Globe:														
No. 1, base station, elevation 1,625	....	50.5	50.0	54.8	67.9	78.2	82.2	84.5	82.8	77.1	70.4	60.8	48.4	67.4
No. 2, E	300	48.2	49.0	54.0	67.8	77.4	80.1	[1] 82.1	[1] 81.3	75.3	68.1	58.1	45.5	65.6
No. 3, summit	1,000	48.0	48.2	53.1	67.3	77.4	80.1	82.1	80.4	74.2	67.3	58.4	45.8	65.2
Gorge:														
No. 1, base station, elevation, 1,400	....	50.0	50.5	56.3	69.7	80.3	83.9	86.3	84.0	77.8	70.9	60.8	47.4	68.2
No. 2, NE	290	50.2	49.6	54.8	68.0	78.5	82.0	84.5	83.4	77.4	69.6	60.0	47.2	67.1
No. 3, S	615	49.1	48.2	53.6	66.4	76.4	79.8	82.4	81.0	75.2	68.4	59.4	46.7	65.6
No. 4, N. (old); NE. (new)	840	48.5	48.0	53.3	67.1	77.4	80.8	82.7	81.4	74.6	67.6	57.9	45.9	65.4
No. 5, summit	1,040	48.0	47.9	53.1	67.0	76.8	80.1	82.2	80.4	73.7	66.4	58.4	45.4	65.0
Hendersonville:														
No. 1, base station, elevation, 2,200	....	[1] 48.9	[1] 49.8	[1] 53.4	67.2	76.7	80.6	83.0	81.2	75.0	68.0	59.1	47.2	65.8
No. 2, E	450	[1] 47.6	[1] 47.0	[1] 50.2	64.6	74.6	78.5	80.7	79.2	73.3	65.9	57.1	45.9	63.7
No. 3, E	600	[1] 47.1	[1] 46.6	[1] 49.7	63.8	73.7	77.5	80.2	78.5	72.4	64.8	56.5	45.0	63.0
No. 4, Summit	750	[1] 46.0	[1] 45.9	[1] 49.0	63.3	73.4	77.2	79.8	78.6	72.6	65.0	56.2	44.6	62.6
Highlands:														
No. 1, base station, elevation, 3,350	....	[1] 45.9	[1] 44.1	[1] 48.6	62.8	72.4	75.9	77.6	76.8	71.6	64.4	56.6	45.8	61.9
No. 2, SE	200	[1] 47.3	[1] 47.4	[1] 47.9	62.6	73.0	76.2	77.4	77.1	71.8	64.6	56.2	46.6	62.5
No. 3, SE	325	[1] 43.1	[1] 42.9	[1] 46.1	60.7	73.0	73.8	75.4	75.1	69.2	62.4	54.4	43.9	60.0
No. 4, SE	525	[1] 43.1	[1] 42.0	[1] 44.2	60.1	70.5	73.9	75.8	76.2	68.6	61.5	53.8	42.8	59.4
No. 5, SE	725	[1] 42.7	[1] 41.9	[1] 43.6	60.4	70.8	74.4	76.5	75.4	69.2	[1] 62.2	54.6	43.5	59.6
Mount Airy:														
No. 1, base station, elevation, 1,340	....	49.7	48.7	54.6	68.4	78.5	84.6	85.8	83.0	77.7	69.5	59.2	46.7	67.2
No. 2, W	160	48.4	[1] 47.2	53.6	67.2	78.1	83.3	85.2	82.4	77.1	68.8	58.2	45.5	66.3
No. 3, E	160	48.8	47.4	53.7	66.8	77.4	82.4	84.8	82.3	77.0	68.4	58.2	46.2	66.1
No. 4, Summit	360	47.6	47.0	53.5	66.9	77.2	82.1	84.2	81.7	75.9	67.9	57.8	45.4	65.6

[1] 3-year average. [2] 2-year average.

TABLE 1.—*Monthly and annual average maximum temperatures, 1913–1916*—Continued.

[The differences between the averages at the base station and those of the respective slopes may be seen by simple inspection.]

Principal and slope stations elevation above mean sea level of base station (feet).	Height of slope station above base (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Transon:														
No. 1, base station, elevation, 2,970	....	46.2	43.8	48.4	61.8	71.9	77.1	79.6	78.1	72.7	65.2	54.6	43.8	61.9
No. 2, W	150	44.1	48.0	46.3	60.2	69.8	75.2	77.0	75.8	69.3	61.6	52.4	41.2	59.8
No. 3, W	300	44.1	42.0	46.4	60.7	70.2	75.7	77.8	76.1	70.7	62.9	52.7	41.2	60.0
No. 4, Summit	450	[1] 41.4	[1] 41.1	[1] 43.5	58.4	68.1	73.9	76.1	75.1	69.8	60.7	51.3	40.3	58.4
Tryon:														
No. 1, base station, elevation, 950	....	54.6	54.3	59.2	71.7	81.4	86.2	88.6	86.7	80.9	74.0	63.8	51.8	71.1
No. 2, SE	380	53.4	53.9	59.0	72.0	81.4	83.4	88.1	86.2	80.6	73.2	63.9	51.5	70.6
No. 3, SE	570	52.0	51.9	56.3	69.2	78.8	80.7	85.1	83.8	77.6	68.9	60.7	48.7	68.0
No. 4, SE	1,100	51.6	50.7	55.4	68.0	77.1	79.0	84.2	82.9	77.0	70.4	61.1	48.5	67.3
Wilkesboro:														
No. 1, base station, elevation, 1,240	....	51.4	50.4	56.3	69.8	79.4	85.2	87.5	84.9	79.2	71.8	61.1	48.6	68.8
No. 2, N	150	50.6	49.8	55.8	69.5	79.7	84.6	87.2	84.3	77.6	70.0	60.0	46.9	68.0
No. 3, N	350	50.6	49.3	55.4	68.1	78.0	82.7	84.9	82.7	76.0	69.0	59.4	47.1	66.9
No. 4, W	430	50.0	48.6	54.6	68.0	76.8	82.1	84.5	82.6	75.7	68.0	59.2	46.7	66.4

[1] 3-year average. [2] 2-year average.

TABLE 1a.—*Average maximum temperatures during selected clear periods.*

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations; elevation above mean sea level of base station (feet).	Height of slope station above base (feet).	Clear period—May 19-26, inclusive, 1914.	Clear period—Nov. 1-7 and 22-26, inclusive. 1914.
Altapass:			
No. 1, base station, elevation 2,230	....	80.6	64.3
No. 2, SE	250	80.1	63.7
No. 3, SE	500	78.8	61.3
No. 4, SE	750	77.9	60.9
No. 5, summit	1,000	76.1	59.8
Asheville:			
No. 1, base station, elevation 2,445	....	81.0	62.2
No. 2, N	155	80.4	60.0
No. 2a, S	155	78.4	62.8
No. 3, N	380	77.5	56.2
No. 3a, S	380	80.6	67.6
Blantyre:			
No. 1, base station, elevation 2,090	....	83.0	66.4
No. 2, NW	300	84.1	65.6
No. 3, NW	450	83.5	65.5
No. 4, NW	600	84.6	66.5
Blowing Rock:			
No. 1, base station, elevation 3,130	....	75.8	58.0
No. 2, S	450	74.0	58.1
No. 3, SE.,	450	73.1	55.8
No. 4, SE	625	73.5	58.2
No. 5, SE	800	72.8	55.9
Bryson:			
No. 1, base station, elevation 1,800	....	84.7	67.4
No. 2, N	385	84.9	65.5
No. 2a, S	385	84.5	67.8
No. 3, summit	570	86.0	65.5
Cane River:			
No. 1, base station, elevation 2,650	....	79.8	61.2
No. 2, N	190	78.8	60.8
No. 3, NE	400	78.6	56.0
No. 4, summit	1,100	81.8	58.3
Ellijay:			
No. 1, base station, elevation 2,240	....	80.9	66.2
No. 2, N	310	82.1	63.8
No. 3, N	620	79.1	63.6
No. 4, N	1,240	78.8	58.8
No. 5, summit	1,760	77.5	60.3

TABLE 1a.—*Average maximum temperatures during selected clear periods*—Continued.

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations: elevation above mean sea level of base station (feet).	Height of slope station above base (feet).	Clear period—May 19-26, inclusive, 1914.	Clear period—Nov. 1-7 and 22-26, inclusive, 1914.
Globe:			
No. 1, base station, elevation 1,625	....	84.0	67.2
No. 2, E	300	83.8	62.0
No. 3, summit	1,000	83.9	65.3
Gorge:			
No. 1, base station, elevation 1,400	....	87.1	67.8
No. 2, NE	290	85.2	66.2
No. 3, S	615	82.9	66.0
No. 4, NE	840	83.2	67.1
No. 5, summit	1,040	82.6	65.5
Hendersonville:			
No. 1, base station, elevation 2,200	....	82.6	65.2
No. 2, E	450	81.0	61.9
No. 3, E	600	79.6	62.0
No. 4, summit	750	79.0	61.5
Highlands:			
No. 1, base station, elevation 3,350	....	76.2	60.1
No. 2, SE	200	78.2	64.1
No. 3, SE.,	325	74.6	58.8
No. 4, SE	525	74.2	57.7
No. 5, SE	725	75.9	60.8
Mount Airy:			
No. 1, base station, elevation 1,340	....	85.1	65.0
No. 2, W	160	85.1	62.7
No. 3, E	160	83.2	63.1
No. 4, summit	360	83.6	62.8
Transon:			
No. 1, base station, elevation 2,970	....	77.6	58.3
No. 2, W	150	75.6	55.6
No. 3, W	300	77.2	55.8
No. 4, summit	450	74.4	55.3
Tryon:			
No. 1, base station, elevation 950	....	87.5	72.0
No. 2, SE	380	89.0	71.6
No. 3, SE	570	83.4	69.2
No. 4, SE	1,100	81.5	68.3
Wilkesboro:			
No. 1, base station, elevation 1,240	....	87.1	67.5
No. 2, N	150	85.8	66.2
No. 3, N	350	83.9	65.7
No. 4, W	430	83.2	64.8

TABLE 1b.—*Average differences between the maximum temperatures at the base station and those higher up on the three long slopes of Altapass, Ellijay, and Gorge on selected days of cloudy weather in 1915.*

ALTAPASS.	Feet.	Difference.	ELLIJAY.	Feet.	Difference.	GORGE.	Feet.	Difference.
No. 1, base station	....	....	No. 1, base station	....	....	No. 1, base station	....	....
No. 2, SE. slope	250	−0.7	No. 2, N. slope	310	−0.7	No. 2, NE. slope	290	−0.7
No. 3, SE. slope	500	−1.5	No. 3, N. slope	620	−2.1	No. 3, S. slope	615	−1.8
No. 4, SE. slope	750	−2.1	No. 4, N. slope	1,240	−3.7	No. 4, W. slope	840	−2.4
No. 5, summit	1,000	−3.2	No. 5, summit	1,760	−5.4	No. 5, summit	1,040	−3.0
Average, 1° for each 312 feet.			Average, 1° for each 326 feet.			Average, 1° for each 347 feet.		

TABLE 1c.—*Monthly and annual average maximum temperatures on six long slopes and rate of decrease with elevation, 1913–1916.*

[The slopes selected for this comparison have a difference in elevation 1,000 feet or more between base and summit stations. The differences in temperature between the base and summit stations are given, as well as the difference in feet, for each degree difference in temperature.]

Slopes and stations.	Elevation (feet).[1]		Month.												
	Base.	Summit.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Altapass, No. 1	2,230	....	[2] 47.4	[2] 47.3	[2] 50.7	[2] 65.7	75.0	79.3	82.0	81.2	74.9	68.2	58.6	46.8	64.8
Altapass, No. 5	....	1,000	[2] 43.1	[2] 42.7	[2] 46.6	[2] 61.5	70.8	75.3	77.7	76.9	71.2	63.8	54.6	43.0	60.6
Difference	....	....	−4.3	−4.6	−4.1	−4.2	−4.2	−4.0	−4.3	−4.3	−3.7	−4.4	−4.0	−3.8	−4.2
Feet for 1° difference	....	....	233	217	244	238	238	250	233	233	270	227	250	263	238
Cane River, No. 1	2,650	....	[2] 47.9	[2] 46.0	[2] 48.5	63.6	74.1	78.5	81.3	80.7	75.1	66.9	57.2	45.7	63.8
Cane River, No. 4	....	1,100	[2] 44.1	[2] 42.9	[2] 46.1	62.6	74.6	77.2	79.0	77.4	70.7	62.8	54.4	42.9	61.2
Difference	....	....	−3.8	−3.1	−2.4	−1.0	+0.5	−1.3	−2.3	−3.3	−4.4	−4.1	−2.8	−2.8	−2.6
Feet for 1° difference [4]	....	....	289	355	458	1,100	2,200	846	478	333	250	268	393	393	423
Ellijay, No. 1	2,240	....	[2] 51.4	[2] 51.0	[2] 53.6	68.1	78.1	81.8	83.8	83.1	78.2	70.3	61.3	49.8	67.5
Ellijay, No. 5	....	1,760	[3] 45.8	[3] 46.0	[2] 48.2	[2] 63.0	[2] 72.7	[2] 75.3	[2] 77.0	[2] 76.8	[2] 72.1	[2] 64.4	[2] 55.0	[2] 44.1	61.7
Difference	....	....	−5.6	−5.0	−5.4	−5.1	−5.4	−6.5	−6.8	−6.3	−6.1	−5.9	−6.3	−5.7	−5.8
Feet for 1° difference	....	....	314	352	326	345	326	271	259	279	289	298	279	309	303
Globe, No. 1	1,625	....	50.5	50.0	54.8	67.9	78.2	82.2	84.5	82.8	77.1	70.4	60.8	48.4	67.4
Globe, No. 3	....	1,000	48.0	48.2	53.1	67.3	77.4	80.1	82.1	80.4	74.2	67.3	58.4	45.8	65.2
Difference	....	....	−2.5	−1.8	−1.7	−0.6	−0.8	−2.1	−2.4	−2.4	−2.9	−3.1	−2.4	−2.6	−2.2
Feet for 1° difference	....	....	400	556	588	1,667	1,250	476	417	417	345	323	417	385	455
Gorge, No. 1	1,400	....	50.0	50.5	56.3	69.7	80.3	83.9	86.3	84.0	77.8	70.9	60.8	47.4	68.2
Gorge, No. 5	....	1,040	48.0	47.9	53.1	67.0	76.8	80.1	82.2	80.4	73.7	66.4	58.4	45.4	65.0
Difference	....	....	−2.0	−2.6	−3.2	−2.7	−3.5	−3.8	−4.1	−3.6	−4.1	−4.5	−2.4	−2.0	−3.2
Feet for 1° difference	....	....	520	400	325	385	297	274	254	289	254	231	433	520	325
Tryon, No 1	950	....	54.6	54.3	59.2	71.7	81.4	86.2	88.6	86.7	80.9	74.0	63.8	51.8	71.1
Tryon, No. 4	....	1,100	51.0	50.7	55.4	68.0	77.1	81.4	84.2	82.9	77.0	70.4	61.1	48.5	67.3
Difference	....	....	−3.6	−3.6	−3.8	−3.7	−4.3	−4.8	−4.4	−3.8	−3.9	−3.6	−2.7	−3.3	−3.8
Feet for 1° difference	....	....	306	306	289	297	256	229	250	289	282	306	407	333	289

[1] Base station above sea level; summit above base.
[2] 1913 missing.
[3] 1913 and 1914 missing.
[4] The datum "Feet for 1° difference" obviously fails of any physical significance when the temperature differences between slope stations are quite small.—*Ed.*

TABLE 1d.—*Monthly and annual average maximum temperatures at the two stations having the highest and lowest elevations, respectively, showing the rate of decrease with elevation, 1913–1916.*

Stations.	Elevation (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Tryon, No. 1	950	54.6	54.3	59.2	71.7	81.4	86.2	88.6	86.7	80.9	74.0	63.8	51.8	71.1
Highlands, No. 5	4,075	42.7	41.9	43.6	60.4	70.8	74.4	76.5	75.4	69.2	62.2	54.6	43.5	59.6
Difference	....	−11.9	−12.4	−15.6	−11.3	−10.6	−11.8	−12.1	−11.3	−11.7	−11.8	−9.2	−8.3	−11.5
Number of feet for 1° difference	....	263	252	200	277	295	265	258	277	267	265	340	377	272

Average monthly and annual maximum temperature.—A discussion of Table 1, which latter contains the record of the average maximum temperatures at the respective stations, will now follow. The differences between the readings at the base station and those at higher levels in each group can be had by simple inspection. This discussion will also include a study of the maximum temperature during selected periods of clear weather shown in Table 1a. The latter table has been prepared in order that the reasons for the variations during sunshiny weather may be seen and understood.

On account of the shortness of the periods included in Table 1a, and the great latitude allowed the observers in reading the temperatures to whole degrees, individual comparisons between the respective stations on the slopes do not always show the uniformity expected. Longer periods, if such were available, would be more satisfactory, as the inequalities would then be smoothed out, or, at least, questionable or unusual values would not stand out so prominently as in a short period.

Since the position of the sun relative to the various slopes, has an important bearing on maximum temperature, two clear periods have been selected in Table 1a, and are presented, one in May, 1914, when the sun is high in the heavens, and the other in November, 1914, when its meridian altitude is low.

Before going into the discussion of the individual tables in detail it might be well first to understand the

reasons for the differing amount of insolation received during sunshiny weather on unit areas of slopes of varying inclination and direction, as illustrated by figure 42.

It is quite apparent from a glance at that graph that practically equal insolation is received during the month of June on both north and south facing slopes, as shown by the areas A, B, and D, the degree of inclination of the slope at this season, when the sun is high in the heavens, being a negligible factor.

However, it may also readily be seen that there is a considerable difference in the insolation on a slope according as it faces north or south during the month of December, when the meridian altitude of the sun is low, as represented by the areas C, E, and A. This is because the same amount of insolation is spread out over much greater area on a north-facing slope than on one with a southerly exposure. Likewise, the intensity of the insolation received on a north-facing slope during the winter months will vary with the degree of inclination, as shown by areas C and E, the gentler the slope the more concentrated the insolation. We find, then, higher maxima during the colder months on a southerly slope than on a northerly one simply because the sun's rays on a south-facing slope are more direct and therefore more effective.

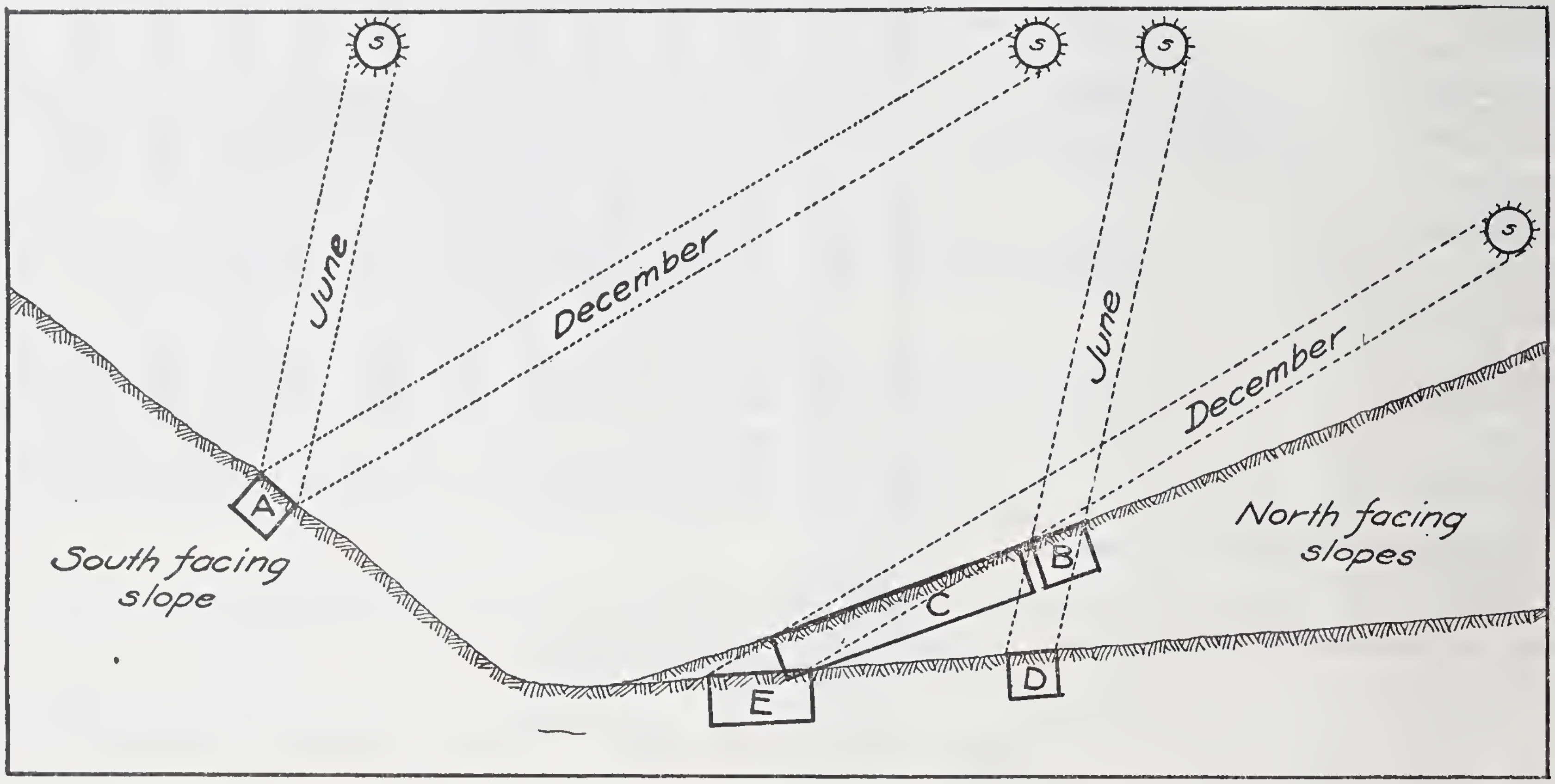

Fig. 42.—Effect of varying inclination and direction of slopes upon maximum temperatures.

Average Maxima on Individual Slopes; Also Maxima During Sunshiny Periods—*Altapass* (Table 1).—There is apparently little seasonal change in the differences between the maxima at the five stations on this long southeasterly slope, the differences for the various months being remarkably uniform throughout the year. The maxima at station No. 1 average the highest during all months, and the readings at the summit station, No. 5, 1,000 feet above, the lowest. The slight variation in these differences from month to month is due to change in shade from near-by timber and vegetation. The average difference for the four-year period between No. 1 and No. 5 is 4.2°, or a decrease of 1° for each 238 feet. As this is a southeast slope, it has considerable sunshine, especially in the morning.

In Table 1a there is shown to be a somewhat greater decrease in maximum temperature with elevation during clear weather than appears in the general average in Table 1 embracing all weather conditions, and this is what should be expected, as the vapor pressure is usually less during clear weather. Moreover, Altapass is a regular slope and the exposures of the various stations are quite uniform. There is a certain harmony between the variations during the two clear periods, especially between the two lower stations and that at the summit.

Asheville (Table 1).—During all the months of the year the maxima at station No. 3 average lowest because of its location on the northerly slope close to heavy timber to the south, west, and east, which permits very little sunshine in the vicinity of the shelter and keeps it in a heavy shade. As the slope is rather steep northerly, the effective rays of the sun are at a minimum in the winter, as shown in Figure 42.

The maxima average highest at station Nos. 1 and 3a, the readings being slightly lower at No. 3a than at No. 1 in the summer months and slightly higher in early spring and late fall months. No. 3a is on a southerly slope, but the timber during the growing season screens the sun to some extent. On the other hand, the sun's rays are more direct on this southerly slope at No. 3a during the winter, resulting then in a higher maximum on sunshiny days than at No. 1.

As might be expected, the maxima at station No. 2a on the south slope average higher than at No. 2 on the opposite northerly slope, taking the year as a whole, but the excess is gained wholly during the fall and winter months, while a small negative difference exists during the late spring and early summer months (see table on page 23). The reason for this apparent anomaly is immediately evident upon consideration of the profile of the valley (fig. 17) and the varying meridian altitude of the sun from December to June. When the sun reaches its lowest meridian altitude in December, 31° in the latitude of the Carolina mountain region, the

south-facing slope at station No. 2a receives about twice as much insolation over a given area as No. 2. But after the vernal equinox, as the sun rises higher and higher, this difference in the amount of heat received becomes such a negligible quantity that it may be disregarded entirely, and it is found that the maximum temperatures are then practically the same at both stations. In June, with the sun's rays from a meridian altitude of 78°, the insolation on both slopes is about equal in amount, but at No. 2a, where the slope is steep and faces a large area of free air, the unstable equilibrium of the surface air is rapidly relieved by interchange.

Another reason for the relatively high maximum during the spring and summer months at No. 2 on the north slope is the fact that there is considerable vegetation surrounding the station which serves to trap the heated air while the location on the north facing slope at No. 2a is almost bare of vegetation.

Four-year average maxima, Asheville, Nos. 2 and 2a and 3 and 3a, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
No. 2, N., 155 feet	49.4	46.7	51.2	64.0	74.8	78.8	81.1	80.2	74.8	66.1	56.9	46.0	64.2
No. 2a, S., 155 feet	50.1	47.7	51.5	63.9	74.0	78.2	80.4	80.2	75.3	67.2	58.2	47.3	64.5
Difference	+0.7	+1.0	+0.3	−0.1	−0.8	−0.6	−0.7	0.0	+0.5	+1.1	+1.3	+1.3	+0.3
No. 3, N., 380 feet	47.0	44.9	49.6	63.0	72.8	75.9	78.0	76.8	70.4	62.4	53.8	43.6	61.5
No. 3a, S., 380 feet	51.0	48.8	52.9	66.3	75.6	79.2	81.2	80.3	74.8	67.8	60.6	48.3	65.6
Difference	+4.0	+3.9	+3.3	+3.3	+2.8	+3.3	+3.2	+3.5	+4.4	+5.4	+6.8	+4.7	+4.1

From an examination of this table it is evident that the maxima at No. 3 on the northerly slope are lower than those at No. 3a with a south exposure during all months of the year, the greatest difference, 6.8°, occurring in November and the least difference, 2.8°, in May. During June, when the meridian altitude of the sun is the highest, practically equal insolation prevails on these two facing slopes (see fig. 42). However, as stated previously, there is a large amount of shade at No. 3 as compared with the conditions in the vicinity of No. 3a, and this effectually screens the sun's rays from the former, especially in the the middle of the day, so that the temperature there is prevented from reaching as high a point as at No. 3a. In December, with the sun at a low meridian altitude, the question of shade, although still a factor, is not so important as the amount of effective insolation received at these two points. Owing to its position on the northerly slope and timber to the east and west, No. 3 at this time of the year is cut off from any rays of the sun, while No. 3a on the opposite slope receives more effective insolation in comparison with that received at No. 3 than it did in June.

For the same reason outlined on a previous page in the comparison between the maxima at No. 2 and No. 2a, the months in which the least and greatest differences occur between Nos. 3 and 3a are May and November, respectively, instead of June and December, as would be expected were the angle of the sun's rays the only factor.

Figure 43 illustrates the effect of shade in reducing the maximum temperature at No. 3 on the northerly slope, as compared with No. 3a on the opposite southerly slope, especially at the time of the year when the meridian altitude of the sun is low. During this clear period, from midnight October 30 to noon November 1, 1913, the maximum temperature on the southerly slope was each day practically 13° higher than on the slope opposite. In the figure are also shown the curves of temperature for the same period for the stations Nos. 2 and 2a on these slopes, but here we have no contrast of sunshine and shade, as at the upper stations, but the effect only of northerly and southerly inclination and varying amounts of vegetation. The maxima on the southerly slope at No. 2a rise to a higher point than at No. 2, but the difference is only 2° or 3°. In the warmer months of the year, when the sun is more nearly overhead, there is no appreciable difference between these two stations on days of sunshine.

In the comparison in Table 1a, the variation in maximum temperature at the two stations on the northerly slope, as compared with those at the base and on the southerly slope during the selected periods of clear weather in May and November, is quite marked, for reasons similar to those already stated.

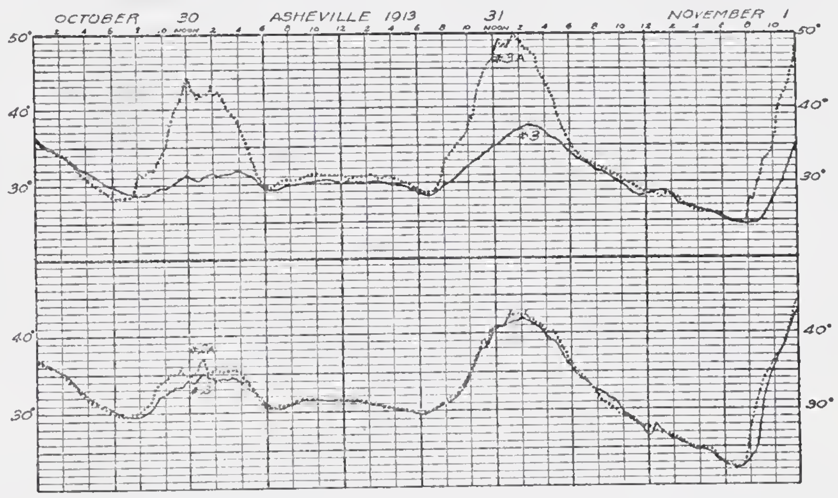

Fig. 43.—Thermograph traces, north and south facing slopes, October 30–November 1, 1913, Asheville: stations 2 and 3 and 2a and 3a are located on opposite slopes facing north and south, respectively.

Blantyre (Table 1).—Disregarding the summit station, the maximum temperature on this slope decreases uniformly with elevation. The average difference between the summit and the base is very slight, and in some months the average at the summit is higher. This is due doubtless to the fact that there is more effective insolation and denser vegetation at the summit station No. 4 than at No. 1, which is really on a small bench on a gradual northerly slope, a slight distance above the valley floor. As there is no month in which the average difference between these two stations approaches the normal rate, there must be a factor or factors working during the entire year to prevent the temperature at No. 1 from reaching higher maxima. The forest growth above and to the south of No. 1 shades this station during much of the time; in the spring and summer on account of the foliage on the trees, and in the fall, even, because the trees, notwithstanding the diminished foliage, offer obstruction sufficient to modify considerably the effect of the sun's heat, although the condition of shade at this point is far from being as pronounced as at station No. 3, Asheville. In the winter the low altitude of the sun becomes an additional factor, while in the summer the excessive cloudiness in the early afternoon aids in cutting down the difference in the maxima between Nos. 1 and 4.

The average difference between the maxima at Nos. 1 and 2 is 0.9° for an ascent of 300 feet, and this is about what should be expected.

Station No. 3 has a lower average maximum than any other of the Blantyre stations during the whole year, because of the fact that the slope is northerly and steep and is ineffectively heated by the sun's rays. The differences between Nos. 1 and 4 and between 3 and 4 are

abnormal. As No. 4 is located on the summit and receives more effective insolation, as previously stated, the maxima at that station are rather high, and this is the case especially in the fall, when the number of clear days is the greatest.

During the clear period in May, as shown by Table 1a, station No. 2 has an average of 1.1° higher than No. 1, and this is largely because the former is located in a sag or gully where the warm air is trapped by the near-by vegetal growth, whereas No. 1 is on a flat bench with but little vegetation in the vicinity, besides being in the shade much of the time, as stated above. This excess of 1.1° at No. 2 over No. 1 is in marked contrast with the four-year average deficiency of 0.9° as shown in Table I, and this is because the latter average includes both clear and cloudy days. No 4 also is higher, while No. 3 on the northwest slope has naturally the lowest maximum in the entire group.

During the November period (Table 1a) station No. 2 shows a more nearly normal rate of decrease as compared with station No. 1, as in this month the vegetation in the vicinity of No. 2 is not a factor. Station No. 3 shows an an increase in the difference between it and No. 1 in November as compared with May, and this is no doubt due to the more effective insolation at No. 1 than at No. 3 during this month, when the meridian altitude of the sun is low, while the effect of shade at No. 1 in November as compared with the station No. 4 on the summit is responsible for the variation in the difference shown in Table 1a between these two locations.

Blowing Rock (Table 1).—In comparing the maximum temperatures at Blowing Rock, it should be understood that there are two groups of stations on different slopes about one-half mile apart, stations Nos. 1 and 2 being located in the China orchard and Nos. 3, 4, and 5 in the Flat Top orchard.

The highest maxima occur at No. 1, although there is very little difference between this station and No. 2. No. 1 is by no means a base station, as both it and No. 2 are on a rather steep southerly slope in the China orchard. No. 2 receives more effective insolation than No. 1, especially in the winter; hence this slight average difference between the stations, 0.3°, although the difference in elevation is 450 feet. The maxima in the China orchard are uniformly higher than those recorded at stations Nos. 3, 4, and 5 in the Flat Top orchard because of the difference in local exposure. Nos. 1 and 2 are situated on a steep narrow slope with high inclosing sides, which tend to prevent a free circulation of air, and thus aid in producing relatively high maxima, while Nos. 3, 4, and 5 have a freer exposure, as they are located on the slope of a huge amphitheater-shaped basin with an opening to the southeast. (See fig. 30.)

During the period of clear weather in May (see Table 1a) the difference between the values at Nos. 1 and 2, —1.8°, is about what should be expected, while there is a difference of only +0.1° in the November period. This variation is undoubtedly due to the fact that in the winter there is more effective insolation at No. 2 than at No. 1, while in the summertime the normal rate of decrease between the two points prevails, as the amount of insolation received at Nos. 1 and 2 is practically equal. For the same reason there is a seasonal variation in the rate of decrease between Nos. 2 and 3 in that No. 2 averages 0.9° higher in the May period and 2.3° higher in the November period.

Bryson (Table 1).—The differences between the maxima at Bryson do not vary materially for the entire period, but there is a remarkable seasonal variation noted between Nos. 1 and 3, the base and the summit stations. Beginning with February, the temperature at No. 3 exceeds that at No. 1, culminating in the month of April with a four-year average excess of 3.7°. With the advance of the season, the difference gradually becomes less and less until July, when it becomes a deficiency which increases to an average of 2° in December. This change is quite uniform throughout each of the four years of record and may be due to the rapid growth of vegetation in the vicinity of No. 3 in the early spring, although this could not be considered a factor as early as February. However, the excess in maximum temperature at No. 3 does not begin until toward the close of that month, the vegetation there doubtless reaching its maximum density in May. The peculiar situation at No. 3 is probably due to some extent at least to the surrounding vegetation and timber in the vicinity, which trap the warm air. The condition is purely local, and the temperature oscillates considerably on sunshiny days during the months in which the excess is noted, especially in the spring.

The difference in height between the summit and the base being 570 feet, the average decrease in temperature of 2°, as noted in December, does not differ much from the normal rate in strong contrast with the excess of 3.7°, noted in April. The average excess at the summit in April, 1914, amounted to 4.6°, while the average deficiency in September, 1916, was 3.9°.

Of course, where sunshine is a principal factor in governing a variation, the monthly average differences should depend upon the relative frequency of sunshiny days, the greater the amount of sunshine the more marked the excess or deficiency as the case may be, while in months with an excess of cloudiness the differences in the maximum temperature should depend almost entirely upon elevation. For instance, in July, 1916, a cloudy month, the average deficiency at No. 3 as compared with No. 1 was 1.8°, while in July, 1913, a sunshiny month, the average excess at the summit station was 0.3°.

The variation in maximum temperature between the the northerly and southerly slopes at both Asheville and Bryson is consistent in the various months of the year, as shown by the table below, in that the excess on the southerly slope is greatest at both places during the winter season, when the sun is farthest south, with the most insolation on a south-facing exposure. The excess on the northerly slope is greatest at Asheville from May to July, inclusive, and at Bryson from July to September, but at Bryson the differences in the summer are very slight. This table indicates the mean differences by months for stations No. 2 and No. 2a at both Asheville and Bryson. The grades of these slopes are not the same, so that, of course, the comparison will serve only in a general way.

Four-year average maxima, Asheville and Bryson, Nos. 2 and 2a, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Asheville:													
2, N., 155 feet.......	49.4	46.7	51.2	64.0	74.8	78.8	81.1	80.2	74.8	66.1	56.9	46.0	64.2
2a, S., 155 feet.......	50.1	47.7	51.5	63.9	74.0	78.2	80.4	80.2	75.3	67.2	58.2	47.3	64.5
Difference..	+0.7	+1.0	+0.3	−0.1	−0.8	−0.6	−0.7	0.0	+0.5	+1.1	+1.3	+1.3	+0.3
Bryson:													
2, N., 385 feet.......	50.6	51.1	54.1	68.9	79.4	82.8	84.8	84.2	79.2	70.4	59.8	46.4	67.6
2a, S., 385 feet.......	52.3	52.2	55.1	69.8	79.7	82.9	84.7	83.8	79.0	71.4	61.6	48.2	68.4
Difference..	+1.7	+1.1	+1.0	+0.9	+0.3	+0.1	−0.1	−0.4	−0.2	+1.0	+1.8	+1.8	+0.8

Cane River (Table 1).—The maxima do not decrease here with elevation through the various months of the year with any regularity. The readings at station No. 3, 400 feet above the base, are unusually low, and those at No. 4 relatively high; in fact, for the four-year period No. 4 averages 0.4° higher than at No. 3, which is 700 feet lower down.

No. 3, which is in a cove-like depression on a north slope, with Rocky Knob towering above to the south and timber in most directions except southeast, is not only cut off from sunshine during much of the morning and afternoon, but the slanting rays of the sun on the steep slope are ineffective in raising the surface temperature. This condition, of course, is most marked during the sun's lowest meridian altitude, and the difference in insolation as reflected in the daytime temperatures at Nos. 3 and 4 is well shown in figure 44.

A seasonal variation is noted between No. 3 and No. 1 in that the maximum at No. 3 is much lower than that at No. 1 in the colder months of the year, and we would expect on this account to find the greatest average monthly difference between the maxima at No. 1 and No. 3 in December, but this actually occurs in October and November, because of the large number of sunshiny days in those months. During the month of October, 1914, the average difference between the maxima at Nos. 1 and 3 on 8 cloudy days was 1.7°, while on 17 clear days the average difference was 7.6°. The greatest difference on any cloudy day was 5°, while on one clear day the difference was 13° and on a majority of the 17 days the differences were 8° or more.

Now, taking the month of May, 1914, a month unlike October in that the altitude of the sun is then higher, when its rays reach into the cove at No. 3, thus producing more equal insolation at Nos. 1 and 3 than during October when the altitude of the sun is lower, we find an average difference of 1.7° between Nos. 1 and 3 for 7 cloudy days, exactly the same as during a period of cloudy weather in October, 1914; while on 18 clear days in May the average difference is only 1.5°, compared with an average difference of 7.6° in a period of clear weather in October, 1914. On 1 cloudy day in May, 1914, the extreme difference of 5° was noted, while on no one of the 18 clear days was there a difference greater than 3°.

Therefore, in the summer time, when the sun is highest and the rays strike directly down into the cove at No. 3, the differences between the maxim at Nos. 1 and 3 are small as compared with those in the colder months of the year. If June and December were as clear as May and October, the least and greatest ranges between the differences at Nos. 1 and 3 would be found in the former months, but the latter months are taken simply because of the greater number of sunshiny days.

The average decrease, 2.6°, in maximum temperature for the four-year period from No. 1 to summit station No. 4 for an elevation of 1,100 feet is at the rate of 1° for 423 feet. No. 4 is located on a knob with dense timber below on all surrounding slopes, except on the east side, and a vast amount of heated air is trapped in the upper portion of the timber, and this heat, together with that radiated from the surface of the foliage, is felt on the knob. There is, moreover, a clearing around the shelter, permitting free exposure to sunshine at all times, although small brush covers the ground.

In Figure 44 are temperature curves representing Nos. 1, 3, and 4, Cane River, for the two days January 4–5, 1916, which show the great excess in day temperature during sunshine at Nos. 1 and 4 as compared with that at No. 3. On the 4th, a clear, calm day, the maximum at No. 3 was 12° lower than that at Nos. 1 and 4, where the maxima were unusually high, being intensified by the existing calm, while on the 5th, a cloudy day, the differences in maxima were not so marked.

Ellijay (Table 1).—The maxima at Ellijay show greater uniformity than perhaps any other group of stations not only in the four-year averages but in the individual months. With an elevation of the summit station above the base of 1,760 feet on this northerly slope there is an average decrease in maximum temperature of 5.8°, approximately 1° for each 303 feet. No. 4, at an elevation of 1,240 feet above No. 1, shows the only irregularity, doubtless because of the configuration of the slope and the near-by timber, which shut off the sunshine more than at the other stations, especially in the winter months. This slope and that at Altapass are the most regular of all the slopes.

The variation in the maximum temperature during the May clear period (Table 1a) shows a comparatively lower reading at station No. 3 and a higher one at No. 4 than is indicated by the four-year averages. In this case the readings of all the stations are consistent except that at No. 3, which for some reason is not in harmony with the averages at other stations.

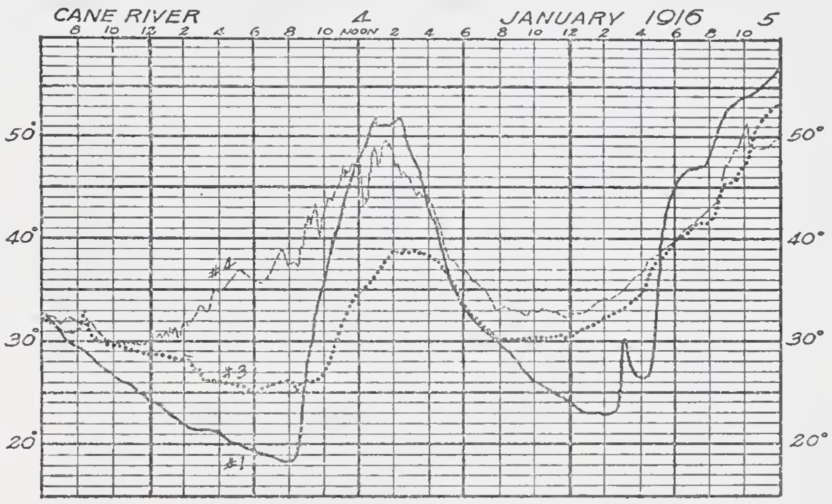

FIG. 44.—Thermograph traces, January 4–5, 1916, stations Nos. 1, 3, and 4, Cane River.

The Ellijay stations, located as they are on a northerly slope, naturally have lower day temperatures as compared with the base during the month of November than in May, and this fact is brought out by the figures in Table 1a, with the exception of those at station No. 3.

Globe (Table 1).—In this group of three stations the maximum readings do not show a decrease approaching the normal rate. Station No. 3, at an elevation of 1,000 feet above No. 1, has a mean maximum only 2.2° lower than No. 1, approximately 1° for each 455 feet. This slight decrease is doubtless because No. 3, the summit station, being located on an arm of Grandfather Mountain, receives a much greater share of insolation than the base. The maxima at No. 2 on the easterly slope, only 300 feet above the base, averages 1.8° lower than No. 1, this large difference being due to the shutting off of the sun at No. 2 by surrounding timber early in the afternoon, especially in the late fall and winter, as stated in description of Figure 35.

In the comparison in Table 1a, the effect of sunshine on elevated sections is shown as compared with those lower down.

A marked seasonal variation between the maxima observed at Nos. 2 and 3 is brought out strongly by the figures in Table 1a. During the period in November

No. 3 averages 3.3° higher than No. 2, located 700 feet below, while in May it averages higher by but 0.1°.

Gorge (Table 1).—At the summit station of Gorge, with an elevation of 1,040 feet above the base, the maximum averages 3.2° lower than at the base, approximately 1° difference for each 325 feet. The average differences for July, September, and October all exceed 4°, while in January and December the average differences are as low as 2°. This variation is due largely to the fact that the sun's rays are far more effective in the warmer months than in the cold months of December and January at the base of a northeasterly slope on which No. 1 is located as compared with the summit. In the latter months, when the sun's rays strike this northeasterly slope obliquely, the maximum readings at all stations on the slope, including No. 1, more nearly approximate the readings at the summit. This is brought out by the figures in the tables and should be compared with the monthly variation on the southeasterly slope at Altapass, for instance, which shows no such variation in maximum temperature differences at its stations in the different months of the year. In fact, at Altapass the maximum temperature in the summer at the summit averages lower than the base station by the same amount as during the winter. The average difference of 4.2° for the four years at Altapass for a difference in elevation of 1,000 feet is even somewhat exceeded in the winter months, January showing a difference of 4.3° and February, 4.6°, while at Gorge, for a difference in elevation of 1,040 feet between the base and the summit, the average four-year difference is 3.2°, but the January and February months have differences of only 2° and 2.6°, respectively. These figures indicate strongly the effect of the direction of the slope on the maximum temperature as modified by the season, which fact is also brought out prominently in the comparisons between the northerly and southerly slope stations at Asheville and Bryson. (See the discussion on those stations.)

The rates of decrease in maximum temperature, 1.1° between Nos. 1 and 2 at Gorge for a difference in elevation of 290 feet and 2.6° between Nos. 1 and 3 for a difference in elevation of 615 feet, are somewhat above the average, but this is not strange, especially as compared with the situation at No. 5, because Nos. 2 and 3 are shut off from sunshine during a considerable portion of the day. The rate, however, at No. 4 shows a smaller value, 2.8° for 840 feet, or 1° for 300 feet. But this statement needs some qualification. No. 4 was located during 1913 and 1914 on a north slope at an elevation of 840 feet above the base, and during 1915 and 1916, on a northeast slope at the same elevation. The maxima were much higher at the first location than at the second as compared with the base station, the average two-year difference between the old No. 4 and No. 1 and between the new No. 4 and No. 1 being 1.8° and 3.8°, respectively. There was a better exposure to insolation at the old location, as the shelter was located on a small ridge with downward slopes on either side to west and east, in the midst of surrounding vegetation such as is likely to be found in any neglected apple orchard; and on sunshiny days the radiation of heat from this vegetation was relatively large. The maxima in 1915 and 1916, however, were low as compared with those at the old location in 1913 and 1914, as the station did not have such a free exposure to sunshine in the later period and there was not as much vegetation surrounding the shelter. Fig. 36 shows the locations of the old and the new No. 4 stations, respectively.

The comparison in Table 1a for the clear periods will serve to bring out more prominently the variation because of sunshine. During the May period the maxima were really lower at all the stations above the base than we should expect, the low reading at No. 3 in the cove at an elevation of 615 feet above the base being the most pronounced.

As a rule during November the maxima on the slope are not so low as compared with the base as in May, and this is probably because of the greater amount of sunshine during months when the foliage has fallen from the trees. This is clearly the case at station No. 4, which, although located on a northerly slope in 1914, has at the same time a free east and west exposure, the location of the shelter being on a ridge or hogback.

Hendersonville (Table 1).—The maximum at the summit averages 3.2° lower than at the base station for a difference in elevation of 750 feet, a rate of 1° for each 234 feet, and this does not seem to be due so much to the fact that No. 4 is low as it is that No. 1 is rather high. The difference is quite marked between Nos. 1 and 2, 2.1° for 450 feet, but the decrease between Nos. 2, 3, and 4 is smaller and quite regular. The maximum at No. 1 reaches a high point on days of sunshine, as it is located in a pocket surrounded by trees on all sides except to the southeast, thus trapping the air and preventing free circulation.

The decrease in maximum temperature with elevation during the clear period in May, 1914, as shown by Table 1a, is somewhat greater between Nos. 3 and 4 than the four-year average decrease and less between stations Nos. 2 and 1, and this variation, as well as that between the May and November clear periods, is due to the effect of wind direction. During the week in May the weather was characterized by light variable winds, mostly southerly with frequent calms, while in the period in the fall the winds were light to moderate northwesterly. The small average difference between the maxima at Nos. 1 and 2 in May is accounted for by the fact that during this period with southerly winds No. 2, being located in a basin protected by a ridge to the south, has relatively high maxima. In fact, high temperatures are observed at this location during periods of calm also, as there is no interchange of air between the saucer-shaped depression where No. 2 is situated and the free air outside. In November, with light to moderate northwest winds, a circulation is produced at No. 2 as this station is not then protected from such winds, which condition prevents high maxima as compared with No. 1, where the question of wind direction and velocity is not a factor. For this same reason station No. 3 averages 1.4° lower than No. 2 in May and 0.1° higher in November. It is therefore apparent that No. 2 has relatively high maxima in the spring and relatively low maxima in November, during both periods the wind direction not being a factor at either No. 1 or No. 3. In other words, Nos. 1 and 3 are what might be termed "constants" and No. 2 the "variable."

This effect in wind direction is strikingly shown by the daily maximum readings at Hendersonville on three successive days in November, 1914, and the following table will serve to illustrate the differences in maximum temperatures under varying wind directions and velocities.

Date.	Maximum temperatures.			Wind direction and velocity.
	No. 1.	No. 2.	No. 3.	
Nov. 23, 1914	53	46	47	Light northwest winds.
Nov. 24, 1914	48	47	48	Do.
Nov. 25, 1914	61	56	57	Do.

Highlands (Table 1).—Stations Nos. 1 and 2 are in the Satulah orchard under conditions much unlike those obtaining in the Waldheim orchard 2 miles distant, where Nos. 3, 4, and 5 are located. While the maxima at No. 2, 200 feet above No. 1, should, because of elevation, average slightly lower, the four-year mean is 0.6° higher, doubtless because of the radiation of heat from Mount Satulah, the immense rock which stands to the north and northeast immediately above. This temperature excess at No. 2 over No. 1 is greatest in the winter, when the sun is in the south and its rays more directly strike the side of the rock above No. 2. Moreover, No. 2 is located in an orchard in the midst of rather high grass and fruit trees, the heated air being trapped by the surrounding vegetation, while No. 1 is over comparatively bare soil. On many sunshiny days the excess in maximum temperature at No. 2 is large, while during periods of cloudiness and precipitation No. 2 averages lower than No. 1.

During the month of December, 1914, when the average maximum temperature at No. 2 exceeded that at No. 1 by 3.5°, the average excess at No. 2 on nine days with sunshine was 5.3°, while on nine days without sunshine the average was 2.6°. On one clear quiet day No. 2 recorded a maximum of 45°, while No. 1 recorded 35°, a large difference, considering the short distance between the two stations. During July, 1916, a month with excessive precipitation and much cloudy weather, the the average difference between the maxima at Nos. 1 and 2 was 1.0°, No. 2 in this case averaging lower than No. 1. In July, 1914, a month with little precipitation and much sunshine, No. 2 averaged 1.5° higher than No. 1.

The rate of decrease in maxima between No. 1 in the Satulah orchard and No. 3, the base station in the Waldheim orchard, 1.9° for 325 feet, is greater than the normal rate, doubtless because of the better exposure to insolation at No. 1 as compared with that at No. 3. However, the variation between Nos. 3 and 4, 0.6° for 200 feet, is practically normal. But No. 5, 200 feet above No. 4, has actually a higher average maximum than No. 4 by 0.2° for the four-year period. Although both stations are on a slope, the slope is steeper at No. 4 than at No. 5, and therefore the maxima at the latter would more nearly approach those found over level places. No. 4 has thus a freer exposure than No. 5 because of the above fact and also because No. 5 is protected on the west and south by forest growth, which is not found around No. 4. The excess in average maximum temperature at No. 5 over No. 4 is due wholly to the gain made on days of sunshine, the readings being actually lower on cloudy days.

The variation at Highlands during the selected period of sunshine in May shown in Table 1a is rather irregular, but conforms to the statements in foregoing paragraphs, and the variation in the November period is much the same as in May.

Mount Airy (Table 1).—The maxima average lower from the base to the summit, but the range in elevation at Mount Airy, of course, is not great. There are differences of 0.9° and 1.1° between Nos. 1 and 2 on the west slope and between Nos. 1 and 3 on the east slope, respectively. Both slope stations are 160 feet above the base, while the decrease in temperature between Nos. 1 and the summit station, No. 4, for a difference in elevation of 360 feet is 1.6°.

Station No. 1 averages rather high in comparison with the other stations because of its exposure on a broad bench, where there is a large amount of radiating surface. No. 2, on the west slope at an elevation of 160 feet above the base, averages for the four-year period 0.2° higher than No. 3 at the same elevation on the east slope, and it is found to be generally the case that the average maxima on the west side are higher. Moreover, the excess at No. 2 over No. 3 is largely in the warmer season of the year, as shown by the following table, which gives the averages and differences for the four-year period for the two stations:

Four-year average maxima, Mount Airy, Nos. 2 and 3, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December	Annual.
No. 2, W., 160 feet	48.4	47.2	53.6	67.2	78.1	83.3	85.2	82.4	77.1	68.8	58.2	45.5	66.3
No. 3, E., 160 feet	48.8	47.4	53.7	66.8	77.4	82.4	84.8	82.3	77.0	68.4	58.2	46.2	66.1
	−0.4	−0.2	−0.1	+0.4	+0.7	+0.9	+0.4	+0.1	+0.1	+0.4	0.0	−0.7	+0.2

Plus (+) sign excess and minus (−) sign deficiency of No. 2 as compared with No. 3.

From a study of this table it is evident that the seasonal variation in maximum temperature between Nos. 2 and 3 is due almost wholly to the varying angle of the sun's rays from month to month as they fall upon slopes of different direction and grade. Beginning with April and continuing through the summer and into the fall, No. 2 is warmer because at the time of maximum temperature the sun's rays are more effective at that station than at No. 3 on the east slope, as brought out by the topographical map (see fig. 39). In the winter the rays of the sun, although coming from a lower altitude, fall upon No. 3 almost perpendicular, because at that location the ground slopes downward to the south as well as to the east, while at No. 2 the slope is distinctly westward, the insolation therefore reaching the station from the side. This seasonal variation is more strongly shown in Table 1a, a discussion of which is given in the following paragraphs.

During the sunshiny period in May, 1914 (Table 1a), No. 2 on the west slope averages exactly the same as the base, while the station on the east slope at the same elevation, 160 feet above the base, averages 1.9° lower than the base, conforming generally to the theory that, during sunshiny weather a west exposure has a higher day temperature than an easterly slope. The summit, station, 200 feet above No. 3, has also a higher temperature than this easterly slope station during the period.

The variation in maximum temperature during the clear period in November (Table 1a) is much the same as in May, with the exception of No. 2 on the west slope, which averages 2.3° lower than No. 1, while there is no difference between these two stations in the spring. Here, again, it is a question of insolation, the sun being low in the south in November and its rays striking No. 2 from the side with small heating effect as compared with their influence on the level surface at No. 1. The seasonal variation between Nos. 2 and 3 is well shown in this table for the reasons advanced in a preceding paragraph, No. 2 averaging 1.9° higher than No. 3 in May and 0.4° lower in November. Because of the varying effect of insolation at No. 1 and No. 4, there is a variation of 0.7° between the average differences for the two periods, No. 4 being the lower, as would be expected, in both cases.

Transon (Table 1).—There is no regularity in the relation between the maxima at the Transon stations. No. 2 on the west slope, 150 feet above the base, averages 2.1° lower, or about 1° for 71 feet difference in elevation; yet at No. 3, 150 feet higher up, the average maximum is actually 0.2° higher than at No. 2. On the other hand,

No. 4, on the summit, with an elevation of 450 feet above the base, averages 3.5° lower than the base. Either the readings at Nos. 1 and 3 must be rather high or those at Nos. 2 and 4 rather low for their elevation. As a matter of fact, both of these conditions may be true. No. 1 is in a cove, the country to the east and to the west being rather flat for a mountainous section and with considerable vegetation around the shelter, while No. 3 has a free exposure toward the west, with ample sunshine. But even here the decrease from the base station up the slope is considerable, 1.9° for 300 feet. So it must be considered that the base station, at least, has relatively high maxima. No. 4, of course, has a free exposure on the summit of a small knob with but little vegetal cover, and therefore its maximum temperatures are lower than No. 1, especially on clear days, assuming, of course, that the sunshine at the base station is not cut off materially. On some days the maxima at No. 4 are actually 8° lower than at No. 1. During November, 1914, the average difference for 21 clear days was 4°, with an extreme difference of 8°, while during a period of clear days in May, 1914, the average difference was 3.6°, with an extreme difference of 6°. On cloudy days the differences ranged from 0.6° to 2.3°.

In a comparison of the maxima during the May period of clear weather (Table 1a) the relations between stations Nos. 1, 2, and 4 seem to be about the same as shown by the four-year averages, the differences at these stations, as stated above, being rather large considering the slight elevations. Station No. 3, however, on the west slope, has a relatively high maximum during the period of sunshine, as should be expected.

The variation during the clear period in November is somewhat different from that in May, in that station No. 3 averages considerably lower than the base, the difference being 2.5°, while in May there is a decrease of but 0.4°. However, as in the spring period, the averages at all the upper stations, Nos. 2, 3, and 4, are lower than at the base.

Tryon (Table 1).—The decrease in maximum temperature from the base station, No. 1, to Nos. 2, 3, and 4 is not uniform but most irregular. The slight average difference, only 0.5° between Nos. 1 and 2 for a difference in height of 380 feet, can be accounted for by the large amount of vegetation at No. 2, this causing a relatively high maximum at that point. Moreover, No. 2 is on a rather flat surface on a general southeasterly slope, so that the maximum there approximates closely that at No. 1 in the valley. In fact on sunshiny days the temperature at No. 2 is as high or higher than that at No. 1, while on cloudy days it is often a degree or more lower.

The average maximum at station No. 3, 570 feet above the base, is abnormally low, the average decrease being 3.1°, equivalent to 1° for 184 feet. There is, moreover, an average decrease of 2.6° from No. 2 to No. 3, although the difference in elevation is only 190 feet, amounting to 1° for 73 feet. The No. 2 shelter is located just below the lower edge of a vineyard in a plot of long grass and weeds, while No. 3 is directly above the upper edge in a small orchard where vegetation is rather thin. We should expect more than the usual decrease between Nos. 2 and 3, because No. 2 is the more favorably situated for high day temperatures during periods of sunshine; but the unusual difference of 2.6° on an average seems rather difficult to explain.

The apparent discrepancy might be accounted for possibly by assuming that the thermometer at No. 3 registered 1° too low, but this supposition is hardly justified, because of the close attention given to the instruments.

In connection with the above, it is interesting to note that the maximum at the summit station in its relation to the base, 1,100 feet below, appears to be normal, as there is a decrease between the two of 3.8°, or 1° for 289 feet. This fact makes the maximum readings at station No. 3 appear even more strange, that station averaging only 0.7° higher than No. 4, although the difference in elevation between Nos. 3 and 4 is 530 feet. In fact, No. 4 conforms so closely to what should be expected for all the months of the year that the record at that point does not require detailed discussion.

The comparison of the selected sunshiny periods (Table 1a) does not explain the apparent anomaly at station No. 3. The average of the maxima at No. 2 during the period of clear weather in May is 1.5° higher than the base station, but the average at No. 3 is 4.1° lower. In the selected May period No. 4 has a comparatively low maximum, being 6° lower than the base.

In the November clear period (Table 1a), the variation is more regular, as there is a gradual decrease from the base to the summit, the difference being relatively great between stations Nos. 2 and 3, but not nearly so great as during the May period.

Wilkesboro (Table 1).—Station No. 1 is located in a comparatively flat open plot on a bench although not so extensive as that at Mount Airy, but sufficiently so to cause relatively high maximum temperatures. Moreover, No. 2, 150 feet, and No. 3, 350 feet, above the base, are located on northerly slopes, and therefore their maxima are relatively low. No. 4 also has a rather low maximum, with a decrease of 2.4° for an elevation of 430 feet above the base. The markedly superadiabatic rate of decrease in temperature is undoubtedly due to the character of the exposure of No. 1, which is unduly heated on sunshiny days during the entire year; but the more direct insolation and the retarded air movement over the flat surface, with the increased vegetation during the warmer months of the year, produce relatively higher maximum temperatures than in the autumn, when the effect of vegetation is practically at a minimum. Nos. 2, 3, and 4 are ideal slope stations with open exposure, which in itself would be sufficient reason for the relatively low maximum temperatures at these locations as compared with No. 1 in all months of the year.

During both sunshiny periods, as shown by Table 1a, the decrease is much greater at Wilkesboro than the four-year averages would indicate. Considering the shortness of the slope, the decrease in maximum temperature is greater here than at any other place, there being a decrease of 3.9° for a difference in elevation of 430 feet between No. 1 and No. 4.

Variations in maximum temperature in clear and cloudy weather.—The irregularities in clear weather are due largely to local exposure in the shape of timber and topography, which cut off the sunshine in varying degrees near the time of maximum temperature, and to surrounding vegetation, which allows abnormal local heating of the air. There are a number of instances of this abnormal heating, especially at Highlands No. 2, Asheville No. 3a, Blantyre No. 4, Bryson No. 3, Cane River No. 4, Globe No. 3, Transon No. 1, and Tryon No. 2, as brought out under the discussion of maximum temperature on the individual slopes. Generally speaking, this factor is most important during the growing season, probably most effective from May to August, when vegetation is densest, and least effective during the

winter. However, the conditions noted during the selected period in May (Table 1a) are dependent on sunshine at the time of the maximum temperature, but the frequent cloudiness in the afternoon at the time of the maximum temperature during June, July, August, and September minimizes local overheating at these stations, so that the decrease in maximum temperature does not differ greatly from the normal decrease with elevation.

With the approach of clear weather in autumn, the maximum temperature at such stations is again slightly increased, although the decrease in the surrounding vegetation prevents the marked local heating which occurs in April and May. However, it will be noted that the four-year average excess in maximum temperature for November, as shown in Table 1, at the summit stations, Asheville No. 3a and Blantyre No. 4, over those at the bases is about equal to the excess recorded in the spring, but this is not due entirely to the increase in the percentage of sunshine, as is the case at the remaining stations, but rather to other reasons which have been described previously.

for the same reason, a marked difference between the stations Nos. 2 and 3 at Mount Airy in the spring as compared with the readings in autumn, doubtless because the direction of slope is not so important in the spring.

Other instances bearing upon this point will be found, such as the readings at stations Nos. 2 at Globe and No. 3 at Gorge, and Asheville stations Nos. 3 and 3a. Cane River No. 3, located in a cove on a northerly slope, is also another striking example of difference in insolation between spring and autumn. Then there are the relatively high readings in the spring at Bryson No. 3 and Cane River No. 4, both summit stations, due to the large amount of vegetation which traps and radiates the heated air near the shelters.

Rates of decrease in monthly and annual average maximum temperature on six selected long slopes.—The figures in Table 1c show that for the entire period of four years the rate of decrease in average maximum temperature with elevation on the Altapass, Ellijay, and Gorge slopes was greater than during the cloudy period included in Table 1b.

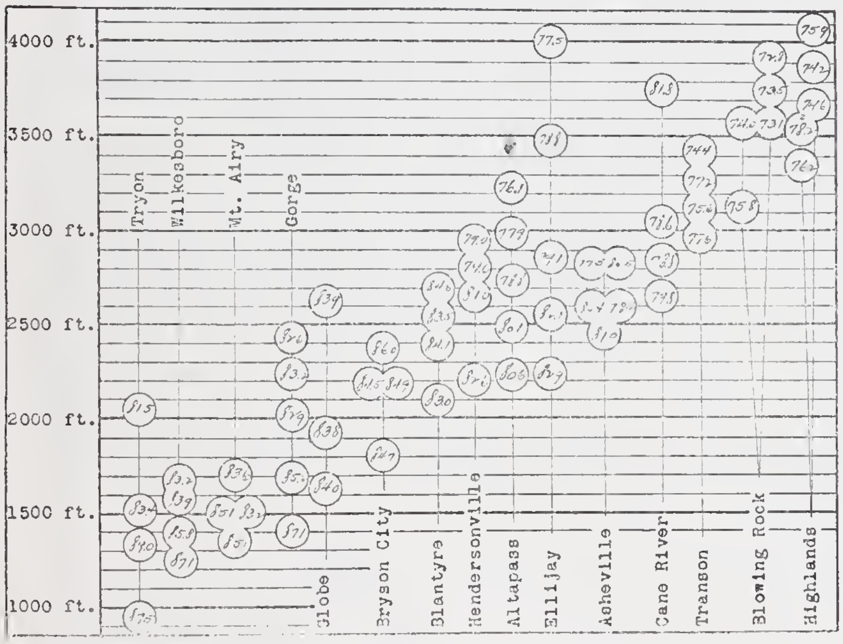

FIG. 45.—Average daily maxima during selected period of clear weather in spring; stations grouped according to elevation above sea level.

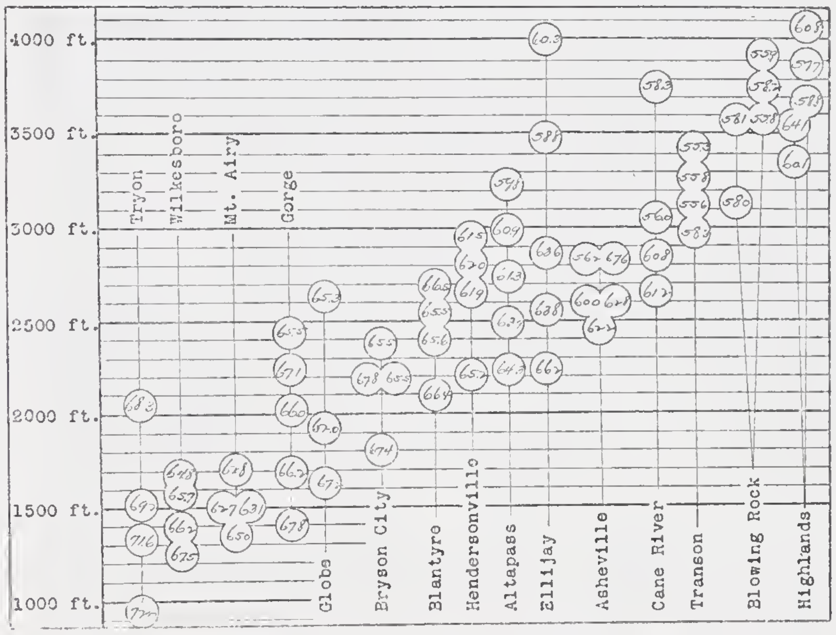

FIG. 46.—Average daily maxima during selected period of clear weather in autumn; stations grouped according to elevation above sea level.

Naturally, there is greater uniformity in the decrease in temperature with elevation during cloudy weather than during days of sunshine, as then the effect of local overheating is avoided.

The figures in Table 1b show the rate of the decrease on selected days of cloudy weather in the year 1915 on the three long slopes having five stations from base to summit, separated from each other more or less uniformly.

The rates of decrease in temperature on these three slopes are fairly uniform at different elevations, and for the slopes as a whole there is a decrease of 1° for each 312 feet at Altapass, each 326 feet at Ellijay, and each 347 feet at Gorge. These rates are all less than the normal rate of decrease in free air—1° for 300 feet—doubtless because of the higher vapor pressure under cloudy conditions.

Figures 45 and 46 furnish a graphic representation of the variation in maximum temperature at all the stations in the research during the selected clear periods in spring and autumn.

The high maximum at Tryon No. 2 in autumn (fig. 46) as compared with the others at the same elevation is due to more insolation on this southeast slope and is in contrast with the slight differences in the averages during the spring period (fig. 45). There is also here apparent,

The largest decrease is found at Altapass, with a rate of 1° for each 238 feet. Ellijay is close to the normal rate for free air, with 1° for each 303 feet, and Gorge less than the normal, with 1° for each 325 feet.

The data are included in Table 1c also for the three other long slopes, Cane River, Globe, and Tryon.

The rates of decrease at Cane River and Globe, 1° for each 423 feet and 455 feet, respectively, are abnormal because of local conditions previously referred to, while the rate at Tryon is about normal, with 1° for each 289 feet.

Monthly and annual average maxima at the two stations having, respectively, the highest and lowest elevations.—A comparison is made in Table 1d for the four-year period between the average maximum temperatures at the lowest and the highest stations employed in the research, Tryon No. 1, 950 feet in elevation, base station, and Highlands No. 5, 4,075 feet in elevation, the summit station. The difference in elevation between these two stations is 3,125 feet, the extreme range employed in this research.

For this difference in elevation there is an average four-year difference in maximum temperature of 11.5°, the greatest average monthly difference being 15.6° in March and the least 8.3° in December.

The rate of decrease for the entire period between these two stations is 1° for 272 feet. The difference in latitude between Tryon and Highlands is negligible in so far as its effects on temperature are concerned, both being located close to the southern boundary of the State.

MINIMUM TEMPERATURE.

Inversions and norms.—The subject of minimum temperature in mountain sections is much more complicated than that of maximum. There is usually a certain uniformity in the variation of mean maximum temperature, because on most slopes there is an average decrease from the lowest to the highest elevations; but no such regular decrease is found in the averages of minimum temperature. This is because on some nights there is a steady decrease in temperature from the base to the summit, on other nights an increase, and on still other nights an increase to a certain point on the slope and then a decrease farther up. So, in the one instance we have the usual decrease in temperature on account of elevation, called here "norm" for the sake of convenience, and in the other two, the variations due to both inversion and norm conditions. There is usually a decrease in minimum temperature from the base to the summit on cloudy or windy nights, while on comparatively clear nights, with little or no wind, an inversion occurs with the lowest temperature in every case at the base. Sometimes, there is even a combination of the two, norm and inversion, as we shall point out later.

Additional types of inversions.—When reference is made in meteorological literature to night inversions, it has been generally understood that they occur only in a region with high pressure, clear weather, and light wind or calm. It is seldom stated that inversions of consequence occur under other conditions, but this study in the Carolina mountain region furnishes additional information on the subject. True it is that the most marked instances of inversion usually occur under high-pressure conditions, but we find that inversions obtain also in the passing of the HIGH and in the approach of the LOW. We have in consequence concluded that inversions may be divided into three different types, the Anticyclonic or Ideal Type, the Recovery or Intermediate Type, and the Cyclonic or Overflow Type.

The Anticyclonic or Ideal Type is of course the one best known, and the best examples of this type occur when the anticyclone persists two or more days.

The Recovery or Intermediate Type is marked by a more rapid movement of anticyclones than in the first-named type, and occurs during the transition from an anticyclone to a cyclone. Inversions of this character are pronounced on only one night, as a rule, but they are sometimes greater than those found under the Anticyclonic Type. The Recovery Type is usually accompanied by clear weather and light winds and is largely due to the stagnation of the colder and heavier air with a further fall in temperature in the hollows and pockets, where the lower stations are located, while the warmer and lighter air above, as it is drawn into an approaching cyclone, flows over the summits and the upper slopes.

The Cyclonic or Overflow Type is characterized by moderate to strong winds and rapidly falling pressure, with a well-developed cyclone approaching. During inversions of this type the low temperatures at the base stations are due to the confinement of air, already cold, in the pockets and narrow valleys, while the strong southerly winds, which usually prevail in the North Carolina region, bring warm air to the higher stations, and although these winds soon draw the colder air out of the pockets, sometimes this does not occur in time to prevent a strong inversion. The Cyclonic Type occurs most frequently in the winter months, when there is pronounced storm activity.

Each one of the three types often merges into one of the two others, so that many of the weaker inversions may be placed in any two of the three types. There is often no sharp line of demarcation between the Intermediate Type and the Cyclonic Type, and yet at other times these two classes have their individual and distinct characteristics.

Anticyclones occasionally dominate the weather in the Carolina mountain region for a week or more at a time, and it is then that pronounced inversions of the Ideal Type occur. No month is without inversions, and rarely a week goes by without one of considerable range. They are most frequent and reach their greatest development during the spring and autumn, with maxima in May and November. In these two seasons the inversions belong almost entirely to the Anticyclonic or Ideal Type, with rarely an inversion of the Cyclonic Type.

Mountain breezes.[3]—So far in the discussion of inversions no reference has been made to certain complications in valleys caused by the direct flow of air downward from above—a subject of considerable moment.

When the air resting above a slope becomes cold compared with the free air over the valley floor, it descends the slope in the form of a night wind or breeze, common in mountain sections, and as such a breeze is not gradual but sudden the air in descending is heated mechanically. This condition is graphically shown by thermograph traces of temperatures on the slope at Asheville No. 2 and on the valley floor at Tryon No. 1, the temperature rising as the rush of air passes the instrument (see figs. 56 and 63). It may be said that in the convective interchange the flow is nonwaterlike, but when air descends the slope in a mountain breeze it is a waterlike flow. In the inclosed valleys or basins such a flow is never observed, but in valleys having an outlet, especially those adjoining deep canyons that afford good opportunities for drainage and where the extent of surface area aloft is great, it is noted frequently.

An example of a sudden rise in night temperatures at a slope station due to the replacement of unusually cold air by the warmer free air adjoining is shown by the thermograph curve at Asheville No. 2, Figure 55, and at Blantyre No. 2, Figure 56; and an example of a rise on the valley floor caused by the downrush of air from the mountain above, as often experienced at Tryon, is illustrated in Figure 62. These figures will be discussed later.

Average monthly and annual minimum temperature.—Table 2, average minimum temperatures and differences, 1913 to 1916, monthly and annual, presents the data much the same as does Table 1 for the maximum, and Table 2a presents data for inversion and norm periods just as Table 1a includes data for periods of clear weather in connection with maximum temperature values. There is, as has been stated before, a much greater variation in the minimum than in the maximum temperature, and we shall note also a much wider variation during inversion than during norm conditions.

Two periods, May 1–6, 1913, and November 2–5, 1916 (Table 2a), have been selected as typical of clear weather in which marked inversions of temperature are noted, the one with gentle to light southerly winds and the

[3] The author is here dealing with the nighttime feature of the well-known phenomenon of mountain and valley winds.—EDITOR.

other with northerly winds, periods with different wind directions being selected, as the direction is an important factor in affecting minimum temperature on nights of inversion.

investigation; and the dates selected in 1916, eight in all, and included in Table 2a, are not consecutive, but they will serve to illustrate the variation in minimum temperature during these special conditions.

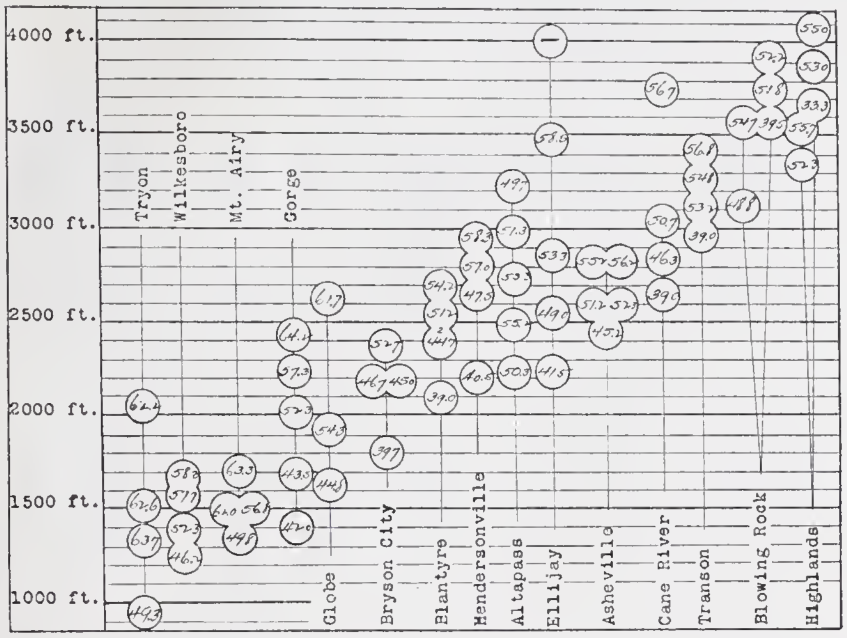

FIG. 47.—Average daily minima during selected inversion periods in spring; stations grouped according to elevation above sea level.

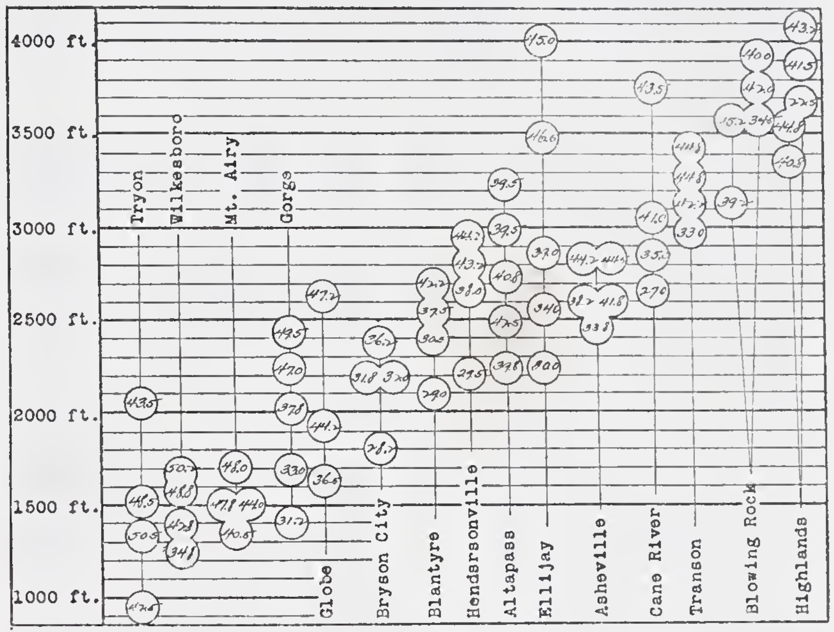

FIG. 48.—Average daily minima during selected inversion period in autumn; stations grouped according to elevation above sea level.

The two periods are probably as representative as any that might be selected, permitting, as they do, the discussion of the question of inversion as far as may seem necessary at this time in connection with the chapter on average minimum temperature. Later the subject of inversion will be treated separately and in greater detail.

It is rather difficult to find a period of several days in succession in which norms occur on all the slopes under

The data for both inversion and norm periods as shown by Table 2a should be helpful in explaining the variations in average minimum temperature on the various slopes. A discussion now follows embracing Tables 2, 2a, 2b, and Figs. 47, 48, and 49, which present data for the various groups of stations.

The average minima to be discussed here will be limited to night readings, just as the average maxima have been limited to day readings.

TABLE 2.—*Monthly and annual average minimum temperatures, 1913–1916.*

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations; elevation of base station above mean sea level (feet).	Height of slope station above base (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Altapass:														
No. 1, base station, elevation 2,230		[1] 31.1	[1] 29.1	[1] 31.5	[1] 44.2	52.8	58.4	62.5	61.3	54.0	46.3	36.6	29.8	[1] 44.8
No. 2, SE	250	[1] 31.5	[1] 29.6	[1] 31.3	[1] 45.3	54.0	59.2	63.1	62.1	55.5	48.2	38.4	30.2	[1] 45.7
No. 3, SE	500	[1] 31.4	[1] 29.3	[1] 30.8	[1] 44.5	53.6	58.6	62.7	62.0	55.3	48.0	37.9	29.7	[1] 45.3
No. 4, SE	750	[1] 29.4	[1] 27.3	[1] 28.9	[1] 42.3	51.8	56.7	60.5	60.1	53.3	46.6	36.2	27.8	[1] 43.4
No. 5, summit	1,000	[1] 29.1	[1] 27.0	[1] 28.8	[1] 42.1	51.0	55.8	60.2	59.5	52.5	45.2	35.4	27.4	[1] 42.9
Asheville:														
No. 1, base station, elevation 2,445		32.3	28.8	32.9	41.8	50.7	56.6	60.3	59.8	52.6	44.6	34.4	28.8	43.6
No. 2, N	155	33.3	29.7	33.6	43.6	52.9	58.0	61.4	60.4	54.6	45.9	36.5	29.5	45.0
No. 2a, S	155	34.5	30.6	34.7	45.0	53.9	59.1	62.4	61.7	55.7	47.5	37.6	30.9	46.1
No. 3, N	380	33.9	30.1	34.1	44.7	54.9	60.0	63.2	62.3	55.6	47.9	38.8	30.8	46.4
No. 3a, S	380	34.5	30.4	34.4	45.4	55.2	60.1	63.4	62.6	56.3	48.4	38.8	30.8	46.7
Blantyre:														
No. 1, base station, elevation 2,090		30.1	26.6	30.2	38.4	47.7	56.1	60.7	60.6	52.8	43.2	29.7	26.0	41,8
No. 2, NW	300	31.4	27.8	32.2	41.6	49.6	56.0	59.8	59.6	51.7	43.0	31.8	27.3	42.6
No. 3, NW	450	32.5	29.2	32.8	43.7	52.1	57.2	61.2	60.6	53.4	45.3	35.5	29.1	44.4
No. 4, NW	600	33.5	30.6	33.8	45.0	54.0	58.4	62.5	61.8	55.3	47.0	37.5	30.3	45.8
Blowing Rock:														
No. 1, base station, elevation 3,130		30.0	26.6	30.2	41.2	50.2	56.9	60.6	60.4	53.6	45.4	35.0	27.2	43.1
No. 2, SW	450	30.0	26.4	29.9	42.4	51.9	57.2	60.9	60.4	53.8	45.8	36.8	27.6	43.6
No. 3, SE	450	27.2	23.4	27.6	37.1	46.1	53.3	56.8	56.3	48.4	42.2	29.6	24.0	39.3
No. 4, SE	625	29.0	25.3	29.0	40.5	50.2	55.9	59.9	59.0	52.4	44.6	35.0	26.2	42.2
No. 5, SE	800	28.0	24.6	28.0	39.6	49.8	55.6	59.2	58.5	51.6	43.8	33.8	25.2	41.4
Bryson:														
No. 1, base station, elevation 1,800		[2] 31.3	[1] 27.4	[1] 28.3	39.4	48.5	55.7	60.0	59.8	52.6	43.1	[1] 30.7	[1] 26.5	[1] 41.9
No. 2, N	385	[2] 32.6	[1] 28.6	[1] 29.5	41.3	49.7	56.0	59.8	59.6	53.0	44.2	[1] 33.6	[1] 27.9	[1] 43.0
No. 2a, S	385	[2] 33.1	[1] 29.0	[1] 29.8	42.4	50.6	56.8	61.2	60.6	53.3	44.1	[1] 33.7	[1] 28.2	[1] 43.6
No. 3, summit	570	[2] 33.8	[1] 29.9	[1] 30.8	44.4	52.3	57.6	61.2	60.8	53.6	46.0	[1] 36.2	[1] 29.0	[1] 44.6

[1] Three-year average.

[2] Two-year average.

TABLE 2.—*Monthly and annual average minimum temperatures, 1913–1916*—Continued.

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations: elevation of base station above mean sea level (feet).	Height of slope station above base (feet).	January.	February.	March.	April.	May.	June.	July.	August	September.	October.	November.	December.	Annual.
Cane River:														
No. 1, base station, elevation 2,650	....	[1] 26.4	[1] 25.7	[1] 27.2	37.6	46.6	53.9	58.1	58.0	49.6	40.4	28.5	24.8	39.7
No. 2, N	190	[1] 29.9	[1] 27.2	[1] 28.9	40.9	49.6	55.4	59.1	58.7	51.3	43.0	33.7	27.6	42.1
No. 3, NE	400	[1] 29.5	[1] 26.1	[1] 27.9	41.3	51.0	56.2	59.8	59.4	52.5	44.4	35.2	27.3	[1] 42.6
No. 4, summit	1,100	[1] 28.8	[1] 26.9	[1] 27.1	41.0	51.3	56.7	60.2	59.6	53.1	45.3	36.3	27.2	[1] 42.8
Ellijay:														
No. 1, base station, elevation 2,240	....	[1] 30.2	[1] 27.7	[1] 28.6	39.7	48.2	54.7	58.8	58.4	51.1	42.5	31.1	27.4	[2] 41.6
No. 2, N	310	[1] 31.1	[1] 30.0	[1] 30.5	42.6	51.0	56.6	59.9	59.0	52.0	43.7	33.8	28.6	[2] 43.7
No. 3, N	620	[1] 31.9	[1] 29.9	[1] 30.5	43.2	52.2	57.1	60.4	59.6	53.3	45.3	36.7	29.7	[2] 44.4
No. 4, N	1,240	[1] 32.8	[1] 30.8	[1] 30.8	45.4	54.8	59.4	62.1	61.2	55.3	47.7	39.1	31.1	[2] 45.8
No. 5, summit	1,760	[2] 32.6	[2] 29.6	[1] 28.6	[1] 44.2	[1] 54.0	[1] 58.4	[1] 60.9	[1] 60.0	[1] 54.7	[1] 48.1	[1] 37.7	[1] 28.6	[1] 44.9
Globe:														
No. 1, base station, elevation 1,625	....	31.8	29.0	32.4	41.9	51.1	58.0	62.0	61.6	54.6	46.5	34.6	29.2	44.4
No. 2, E	300	33.4	30.6	34.3	45.1	55.0	60.5	64.1	63.5	57.0	49.3	38.6	31.2	46.9
No. 3, summit	1,000	33.6	30.4	33.8	46.0	55.9	61.2	64.6	63.5	57.2	49.7	39.8	30.8	47.2
Gorge:														
No. 1, base station, elevation 1,400	....	30.8	28.1	32.3	40.5	49.3	56.8	61.1	61.0	53.9	45.2	32.8	27.9	43.3
No. 2, NE	290	30.6	27.8	32.0	41.2	50.2	57.2	61.0	60.8	53.6	45.1	33.8	28.6	43.5
No. 3, S	615	32.4	29.6	33.6	43.8	52.3	58.0	61.8	61.0	54.2	45.8	36.6	29.7	44.9
No. 4, N. (old); NE. (new)	840	33.0	30.2	34.4	45.6	54.8	59.7	63.2	62.4	55.9	48.0	39.1	30.6	46.4
No. 5, summit	1,040	33.5	30.9	34.4	46.9	57.0	61.4	64.9	63.7	57.7	49.9	41.1	32.0	47.8
Hendersonville:														
No. 1, base station, elevation 2,200	....	[1] 28.9	[1] 27.3	[1] 28.3	38.8	47.8	55.4	59.6	59.8	51.8	43.2	31.1	27.4	42.0
No. 2, E	450	[1] 30.7	[1] 28.5	[1] 30.3	41.7	50.8	57.7	61.1	60.5	53.0	44.9	34.4	28.9	44.7
No. 3, E	600	[1] 31.5	[1] 29.8	[1] 30.7	44.0	53.2	58.7	61.8	61.4	54.7	46.9	37.4	29.7	46.2
No. 4, summit	750	[1] 31.7	[1] 30.0	[1] 30.9	44.6	54.2	59.3	62.6	61.6	55.5	47.8	38.4	30.1	46.8
Highlands:														
No. 1, base station, elevation 3,350	....	[1] 32.2	[1] 28.9	[1] 30.4	44.2	53.2	58.3	61.6	61.0	55.2	47.0	38.0	30.7	45.1
No. 2, SE	200	[1] 33.0	[1] 31.1	[1] 30.2	44.2	53.4	58.5	61.7	61.4	55.3	47.4	38.9	31.8	45.6
No. 3, SE	325	[1] 26.8	[1] 23.4	[1] 24.4	34.6	43.4	49.4	53.5	53.0	45.7	38.0	27.7	23.4	37.0
No. 4, SE	525	[1] 29.0	[1] 25.9	[1] 26.0	41.2	50.7	55.6	58.5	57.6	51.3	44.2	35.8	27.2	41.8
No 5, SE	725	[1] 28.6	[1] 25.7	[1] 25.4	41.5	51.4	56.5	59.8	58.7	52.6	46.0	36.8	28.6	42.5
Mount Airy:														
No. 1, base station, elevation 1,340	....	33.0	30.0	34.6	45.0	53.6	60.5	64.0	63.4	56.3	48.2	37.0	30.2	46.3
No. 2, W	160	34.3	31.4	35.6	47.2	57.2	63.1	66.3	64.7	58.8	51.3	41.0	32.2	48.6
No. 3, E	160	34.0	30.8	35.3	46.4	55.6	61.8	64.7	64.0	57.6	49.7	39.0	31.8	47.6
No. 4, summit	360	33.9	30.8	34.7	46.8	56.8	62.6	66.0	64.9	58.8	51.2	40.6	31.8	48.2
Transon:														
No. 1, base station, elevation, 2,970	....	28.8	24.7	28.4	38.3	46.4	53.3	57.6	56.6	48.8	41.4	30.4	24.5	40.0
No. 2, W	150	30.6	26.4	29.8	41.4	51.2	56.7	59.8	59.2	52.0	43.8	34.9	26.8	42.8
No. 3, W	300	30.4	26.8	29.8	41.8	51.2	57.2	60.6	59.8	52.8	45.1	35.9	27.0	43.2
No. 4, summit	450	[1] 29.1	[1] 27.2	[1] 27.8	42.0	52.3	57.5	60.8	60.0	54.2	46.3	36.9	27.3	43.8
Tryon:														
No. 1, base station, elevation 950	....	34.7	32.3	35.9	44.7	54.8	63.0	66.7	66.3	58.5	50.6	37.3	32.8	48.1
No. 2, SE	380	38.1	36.0	39.4	50.8	60.4	65.7	69.0	67.6	61.4	53.8	44.3	35.9	51.8
No. 3, SE	570	37.6	34.8	38.1	49.7	58.8	64.2	67.5	66.4	59.9	52.2	43.0	34.4	50.5
No. 4, SE	1,100	35.8	33.3	36.2	47.5	56.9	61.9	65.0	64.4	58.0	47.7	40.6	32.8	48.8
Wilkesboro:														
No. 1, base station, elevation 1,240	....	31.6	28.8	33.8	43.4	52.1	59.2	63.3	62.8	55.6	46.4	35.0	29.0	45.0
No. 2, N	150	33.1	30.4	35.2	45.7	54.9	60.6	64.4	63.7	56.2	48.4	37.6	30.7	46.7
No. 3, N	350	34.2	31.8	36.2	47.5	57.0	62.3	66.2	65.0	58.2	50.6	40.6	32.2	48.5
No. 4, W	430	34.2	31.4	35.8	47.4	57.3	62.6	66.5	65.6	58.3	50.6	41.2	32.3	48.6

[1] Three-year average. [2] Two-year average.

AVERAGE MINIMUM TEMPERATURE ON INDIVIDUAL SLOPES, ALSO MINIMA DURING PERIODS OF INVERSION AND NORM.—*Altapass* (Table 2).—The observations on this southeasterly slope show the highest mean minimum temperature to be at station No. 2, 250 feet above station No. 1, and the lowest at No. 5, 1,000 feet above No. 1, the former averaging 0.9° higher and the latter 1.9° lower than station No. 1. The average values at the stations between Nos. 2 and 5 show a gradual decrease, No. 3 averaging 0.5° higher, and No. 4, 1.4° lower, than No. 1. Taking these values as a basis, it is apparent that the highest average minimum temperature on the entire slope is either at No. 2 or slightly above. There is a considerable monthly variation in these means, inversion conditions being more pronounced usually in the autumn months than in any other season of the year, this being due to a combination of longer nights and longer periods of clear weather.

During the critical periods of spring and fall the entire slope from the summit down to No. 1 and lower is usually free from white frost, except on small benches, but with increasing elevation there is always danger from top freeze, the temperature at No. 5 averaging about 5° lower than No. 1 during norm conditions.

On the other side of the Blue Ridge at Altapass, called the Mitchell County side, the descent is very slight, the plateau here being at times flush with the top of the ridge. As would be expected, heavy frosts are observed frequently on the plateau, the general flatness and high elevation being ideal for great loss of heat by radiation in clear weather.

Unusual fluctuations in temperature at Nos. 1 and 2 during anticyclonic weather indicate the development under favorable conditions during the night of a mountain breeze, the air descending from the high plateau through McKinney Gap (see fig. 26.) The unusual frequency of northerly winds also indicates such a mountain breeze.

In Table 2a the variation in average temperatures and differences for the periods of inversion weather bear a certain relation to those shown in Table 2. However, the differences between No. 1 and the stations higher up during inversions apparently do not compare with those

on many other slopes, simply because all the stations at Altapass are located high up above the valley floor. During the May period of inversion, with light southerly winds, the highest minimum is shown to be at station No. 2, 250 feet above No. 1, while the lowest is at the summit, 1,000 feet above No. 1, the excess at the former being 4.9°, and the deficiency at the latter 0.6°. No. 2 is practically in the middle of the thermal belt during this period.

The selected November period of inversions with light northerly winds shows variations between the base, slope, and summit stations similar to those noted in the May period, but in a lesser degree, as this period, taken as a whole, was not so favorable for large inversions as the period in the spring. Again, the influence of northerly winds serves to lessen the differences between the temperatures at the various stations, as these, although gentle to light, bring the colder air from over the plateau on the edge of which No. 5 is situated and lower the temperature on the whole slope, as shown in Table 2a.

During norm conditions (Table 2a) a different situation is apparent, when the temperature gradually decreases from the base to the summit, roughly speaking, at the rate of 1° for about 200 feet. In both inversions and norm conditions the lowest temperature at Altapass is on the average at the summit, and this is consistent with the mean minima data appearing in Table 2. The warmest station during periods of inversion is No. 2 and during norm conditions is No. 1.

TABLE 2a.—*Average minimum temperatures during selected inversion and norm periods.*

Principal and slope stations; elevations of base stations above mean sea level, feet.	Height of slope station above base (feet).	Inversion—May 1–6, inclusive, 1913.	Inversion—Nov. 2–5, inclusive, 1916.	Norm—Eight selected dates, January, February and March, 1916.[1]
Altapass:				
No. 1, Base station, elevation 2,230	....	50.3	39.8	17.5
No. 2. SE	250	55.2	42.5	16.4
No. 3. SE	500	53.3	40.8	15.5
No. 4. SE	750	51.3	39.5	13.4
No. 5. Summit	1,000	49.7	39.5	12.4
Asheville:				
No. 1. Base station, elevation 2,445	....	45.2	33.8	15.5
No. 2. N	155	51.2	38.2	13.5
No. 2a. S	155	52.3	41.8	15.4
No. 3. N	380	55.2	44.2	13.4
No. 3a. S	380	56.2	44.5	14.1
Blantyre:				
No. 1. Base station, elevation, 2,090	....	39.0	29.0	20.5
No. 2. NW	300	44.7	30.5	18.6
No. 3. NW	450	51.2	37.5	17.6
No. 4. NW	600	54.2	42.2	17.9
Blowing Rock:				
No. 1. Base station, elevation 3,130	....	48.8	39.2	13.2
No. 2. S	450	54.7	45.2	11.5
No. 3. SE	450	39.5	34.5	10.9
No. 4. SE	625	51.8	42.0	10.2
No. 5. SE	800	52.2	40.0	8.8
Bryson:				
No. 1. Base station, elevation 1,800	....	39.7	28.2	18.1
No. 2. N	385	45.0	32.0	17.5
No. 2a. S	385	46.7	31.8	17.2
No. 3. Summit	570	52.7	36.2	16.0
Cane River:				
No. 1. Base station, elevation 2,650	....	39.0	27.0	15.0
No. 2. N	190	46.3	35.0	14.5
No. 3. NE	400	50.7	41.0	13.1
No. 4. Summit	1,100	56.7	43.5	9.5
Ellijay:				
No. 1. Base station, elevation 2,240	....	41.5	30.0	18.6
No. 2. N	310	49.0	34.0	18.0
No. 3. N	620	53.3	39.0	15.6
No. 4. N	1,240	58.5	46.5	13.6
No. 5. Summit	1,760	....	45.0	11.5
Globe:				
No. 1. Base station, elevation 1,625	....	44.8	36.5	23.6
No. 2. E	300	54.3	44.2	22.1
No. 3. Summit	1,000	61.7	47.2	18.0
Gorge:				
No. 1. Base station, elevation 1,400	....	42.0	31.2	23.6
No. 2. NE	290	43.5	33.0	22.5
No. 3. S	615	52.3	37.8	20.9
No. 4. NE. (old) N. (new)	840	57.3	47.0	19.0
No. 5. Summit	1,040	64.2	49.5	18.6

TABLE 2a.—*Average minimum temperatures during selected inversion and norm periods*—Continued.

Principal and slope stations; elevations of base stations above mean sea level, feet.	Height of slope station above base (feet).	Inversion—May 1–6, inclusive, 1913.	Inversion—Nov. 2–5, inclusive, 1916.	Norm—Eight selected dates, January, February and March, 1916.[1]
Hendersonville:				
No. 1. Base station, elevation 2,200	....	40.5	29.5	17.4
No. 2. E	450	47.5	38.0	16.5
No. 3. E	600	57.0	43.2	15.1
No. 4. Summit	750	58.3	44.2	14.2
Highlands:				
No. 1. Base station, elevation 3,350	....	52.3	40.8	16.6
No. 2. SE	200	55.7	44.8	15.2
No. 3. SE. base station	325	33.3	22.5	13.4
No. 4. SE	525	53.0	41.5	11.5
No. 5. SE	725	55.0	43.2	10.6
Mount Airy:				
No. 1. Base station, elevation 1,340	....	49.8	40.5	22.9
No. 2. W	160	62.0	47.8	21.1
No. 3. E	160	56.8	44.0	21.4
No. 4. Summit	360	63.3	48.0	20.2
Transon:				
No. 1. Base station, elevation 2,970	....	39.0	33.0	13.4
No. 2. W	150	53.2	42.2	12.5
No. 3. W	300	54.8	44.8	12.1
No. 4. Summit	450	56.8	44.8	11.5
Tryon:				
No. 1. Base station, elevation 950	....	49.3	42.5	25.7
No. 2. SE	380	63.7	50.5	24.6
No. 3. SE	570	62.6	49.1	23.0
No. 4. SE	1,100	62.2	43.5	20.5
Wilkesboro:				
No. 1. Base station, elevation 1,240	....	46.2	34.8	23.9
No. 2. N	150	52.3	42.8	23.0
No. 3. N	350	57.7	48.8	23.2
No. 4. W	430	58.3	50.2	22.8

[1] Jan. 14 and 17, Feb. 3 and 14, Mar. 4, 8, 15, and 16.

Asheville (Table 2).—From the base station, No. 1, the average minimum temperature on the north slope increases gradually up to No. 3, the difference between Nos. 1 and 2 and between Nos. 2 and 3 being exactly the same for the four-year period, 1.4°, or a total of 2.8° between Nos. 1 and 3. The average minima on the south slope from No. 1 to No. 3a also increase with elevation, but the differences are larger, although not so regular, as on the north slope, No. 2a averaging 2.5°, and No. 3a, 3.1°, higher than No. 1.

It should be understood that the stations above the base at Asheville are at the same elevation on two slopes facing each other and inclosing a rather narrow valley. The southerly slope is much steeper than the northerly one, as shown by Figure 17.

The excess in mean minimum temperature at the two highest stations, Nos. 3 and 3a, over the base, No. 1, is greatest in May and November, the months with the most frequent and largest inversions. There is a remarkable uniformity between the minimum readings at the two highest stations in all seasons of the year. In fact, there is also a certain uniformity in the readings at Nos. 2 and 2a. The table below contains the four-year average minima by months for the two sets of stations on these opposite slopes.

Four-year average minima, Asheville, Nos. 2 and 2a and 3 and 3a, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
2, N., 155 feet	33.3	29.7	33.6	43.6	52.9	58.0	61.4	60.4	54.6	45.9	36.5	29.5	45.0
2a, S., 155 feet	34.5	30.6	34.7	45.0	53.9	59.1	62.4	61.7	55.7	47.5	37.6	30.9	46.1
Difference	+1.2	+0.9	+1.1	+1.4	+1.0	+1.1	+1.0	+1.3	+1.1	+1.6	+1.1	+1.4	+1.1
3, N., 380 feet	33.9	30.1	34.1	44.7	54.9	60.0	63.2	62.3	55.6	47.9	38.8	30.8	46.4
3a, S., 380 feet	34.5	30.4	34.4	45.4	55.2	60.1	63.4	62.6	56.3	48.4	38.8	30.8	46.7
Difference	+0.6	+0.3	+0.3	+0.7	+0.3	+0.1	+0.2	+0.3	+0.7	+0.5	0.0	0.0	+0.3

This table shows that both stations on the southerly slope have higher minima than on the northerly slope throughout the year, and this may be partly due to the difference in direction of slope, but the greater steepness of the southerly slope is the main factor. Moreover, the difference in minima is much greater between Nos. 2 and 2a than between Nos. 3 and 3a. The differences in the minima at the two higher stations at the same elevation, however, are slight, and no seasonal variation is apparent, but even here the advantage is with No. 3a on the southerly slope, but to a much less degree than at the lower level at No. 2a, where the slope is steeper.

The differences between the average minima at Nos. 2 and 2a and between Nos. 3 and 3a are slight as compared with the differences between the average maxima, Tables 1 and 1a. The maxima at the upper station, No. 3a, on the south slope are much the higher during sunshiny weather at all seasons of the year and at No. 2a in the colder months. The minimum at No. 3 averages almost as high as the minimum at No. 3a, even though, because of the shade previously referred to its maxima are much lower. In spite of these low day temperatures caused by shade on this northerly slope, the warm free air in the valley on nights of inversion serves to prevent the minimum temperature on that slope from falling appreciably lower than on the opposite southerly slope.

A comparison of the minimum temperature data for the selected periods of inversion (Table 2a) indicates that the thermal conditions on both slopes at Asheville are much the same in the May period, but that they differ in the November period, especially at the elevations of Nos. 2 and 2a. Thus in May stations Nos. 2 and 2a have an average excess over the base of 6° and 7.1°, respectively, while Nos. 3 and 3a, higher up, have average excesses of 10° and 11°, respectively, in each case there being a slight advantage in minimum temperature on the steep southerly slope. In the November period the advantage of a steep southerly exposure is especially marked at No. 2a. Doubtless the center of the thermal belt is located on the slopes at a level considerably higher than Nos. 3 and 3a, but because of the absence of additional stations the exact level can not be determined.

During norm conditions, according to the data in Table 2a, the stations on the northerly slope are relatively colder than those on the southerly slope, but the differences between the base station and those higher up are never great, obviously because of the slight differences in elevation.

Blantyre (Table 2).—In general the average minima here increase from the base No. 1 to No. 4 on the summit. No. 1 is some distance from the remaining three stations, which are located on the slope of Little Fodderstack Mountain, No. 2 being at its immediate base. In the summer months the differences between the minima at all the stations are small as compared with the spring and autumn months, especially April, May, and November, when inversions are frequent. In November, 1913, the average minimum at No. 4 was 9.9° higher than at No. 1, and 8° higher than at No. 2. In the summer, the average at No. 2 is often lower than at No. 1, and in July, 1916, an unusually rainy and cloudy month, all stations averaged lower than No. 1. The month of June, 1915, also cloudy and rainy, shows averages with similar differences.

Station No. 2 may properly be considered a base station, although 300 feet higher than No. 1. The larger amount of vegetation around No. 2 as compared with No. 1 is also an important factor, as shown by the relatively low minima at the former during the warmer months, when the vegetation is densest. Moreover, during these months the differences between No. 1 and the stations higher up are least because of the large amount of vegetation in the orchard as compared with the closely cropped grass around No. 1 below and because of the small range of inversion usually prevalent during the summer.

The considerable differences in average minima between the base and the higher stations are doubtless due to the exceedingly low readings at the lower levels and not to any abnormally high readings at the more elevated stations. The valley of the French Broad at Blantyre is rather wide, with only a slight descending grade, and is inclosed by mountains at a distance. It is much like a vast frost pocket with opportunities for free radiation, resulting in a blanket of very cold air at the lower levels. In fact, considering its elevation above sea level, station No. 1 at Blantyre has, together with Bryson No. 1 and Gorge No. 1, the lowest average minima of all the stations employed in the research.

In the selected periods of inversion (Table 2a) the data show steadily increasing minima from the valley floor to the summit of Little Fodderstack, the No. 4 station averaging 15.2° higher in May and 13.2° higher in November than No. 1. The center of the thermal belt at such times would be above the elevation of the summit station were the slope higher, judging from a comparison of Blantyre No. 4 with the summit stations at Hendersonville and Asheville, which average from 2° to 4° higher than Blantyre during these periods.

During norm conditions at Blantyre, for which data are given in Table 2a, while the warmest station is on the valley floor, the coldest is not at the summit but on the slope at No. 3, 150 feet lower down, the slight average difference of 0.3° between these two stations possibly being due to instrumental error.

Blowing Rock (Table 2).—Here the five stations are divided into two groups, Nos. 1 and 2 of the lower group being in the China orchard on a steep southerly slope and Nos. 3, 4, and 5 of the higher group in the Flat Top orchard on a moderate southeasterly slope (fig. 30). Nos. 2 and 3, although in different orchards about one-half mile apart, are both at the same elevation, 450 feet above No. 1.

No. 2, although the lowest in altitude, is not a valley floor station, while No. 3 is a distinctly valley floor station for the group of stations, Nos. 3, 4, and 5, in the Flat Top orchard. It is for these reasons that the differences be tween the minima at station No. 1 and those higher up do not apparently conform to the differences noted in the groups at Altapass, Ashville, and Blantyre, previously discussed.

In examining the figures in detail by individual months we find that in the months of November and December, 1916, and April, 1915, No. 2 averages, respectively, 3.9°, 3.3°, and 2.8° higher than No. 1, while in September, 1913, a cold and more or less cloudy month, No. 2 averages 1.2° lower than No. 1. Aside from the fact that the largest inversions occur in April, May, and November, there does not seem to be any regularity as to the occurrences of positive or negative differences between Nos. 1 and 2. On November 4, 1916, No. 2 was 10° higher than No. 1, while negative differences of 8° and 9° were noted on individual days in the months of December, 1916, and April, 1915.

These great differences depend almost entirely upon the direction and velocity of the wind, as from an examination of the Blowing Rock contour map, Figure 30, it is evident that under favorable conditions the topography

aids greatly in developing a breeze down the slope at night, which in this region is an exchange of air between the cold plateau to the north of the China and Flat Top orchards and the warmer descending ridges and spurs of the valley of the Johns River and the Middle Fork of the New River. On nights when this wind blows, No. 2 located near the top of the plateau and 450 feet above No. 1, averages colder than the base station, while on nights when this wind is not developed particularly during the prevalence of light southerly winds which are sufficient to check the flow of cold air from the plateau, there are large inversions between Nos. 1 and 2.

All of the stations in the Flat Top orchard show average minima lower than those in the China orchard, and this should be expected, as the Flat Top orchard is a partly inclosed basin with only a very slight slope at the open end, furnishing conditions favorable for a frost pocket. No. 3, the base station in the Flat Top orchard, has, of course, the lowest minimum, the average being 3.8° lower than No. 1 in the China orchard. At No. 3 is found the lowest average minimum temperature of all the experimental stations, except Highlands No. 3, which is also located in a frost pocket, but of a different character.

As in the China orchard, so in the Flat Top orchard, there is evidence of a mountain breeze which occurs under exactly the same conditions, but on nights when No. 2 is colder than No. 1 the minimum at No. 5 is not lower than No. 3, although the excess at No. 5 over No. 1 is greatly reduced during the prevalence of this breeze, and, taking the temperature at these stations hour by hour on such nights, No. 5 is actually colder than No. 3 by several degrees.

During both selected periods of inversion (Table 2a) No. 2 averages 6° higher than No. 1. Nos. 4 and 5 in the Flat Top orchard average, respectively, 12.3° and 12.7° higher than No. 3, its base station, in May and 7.5° and 5.5° higher in November, although their respective elevations above No. 3 are only 175 and 350 feet. These differences in temperature are exceptionally large when the slight differences in elevation are considered. The minimum temperature at No. 3 in the Flat Top orchard during the May period averages 15.2° lower than No. 2 in the China orchard, although both stations have exactly the same elevation.

The effect of wind direction and velocity is again apparent in comparing the average differences in minima between Nos. 3 and 5, as shown in the two selected periods. During the week in May with light southerly winds the temperature at No. 5 exceeds that at No. 3 by an average difference of 12.7°, and on these nights the upper limit of the thermal belt probably extended above No. 5. In November, when the prevalence of the breeze, aided on some nights by northerly winds, increases the temperature at No. 3 and lowers it at No. 5, the difference is reduced to 5.5°, and the middle of the thermal belt on these nights is probably close to No. 4. Of course, during this same period conditions were favorable for a breeze down the slope of the other orchard where Nos. 1 and 2 are located, but no effect upon the temperature conditions was apparent in the average difference between these two stations, because on one of the nights included, November 4, the excess of No. 2 over No. 1 was so marked, 10°, that the deficiencies on the other nights were neutralized in the averages.

During the selected norm period the temperature in each orchard decreases regularly with elevation, but, as is usually the case because of its exposure, No. 3 in the Flat Top orchard has a somewhat lower temperature than No. 2 in the China orchard.

Bryson (Table 2).—The average minimum temperature at the Bryson base station, No. 1, is rather low and agrees closely with that at the base station at Blantyre, which has a slightly higher elevation, the average minima for the four-year period being 41.9° and 41.8°, respectively. These values are both low for the altitude, and this is due to the fact that both stations are located close to a rather wide valley floor with conditions resembling a large frost pocket. The average minima at the more elevated stations at Bryson, Nos. 2 and 2a, on the north and south slopes, respectively, both at an elevation of 385 feet above the base, and at No. 3 on the summit, with an elevation of 570 feet, are consistently higher. While the average excess at No. 2 on the north slope over No. 1 is 1.1°, that at No. 2a on the south slope is greater, 1.7°, there being an average difference of 0.6° between the two slope stations. The difference between No. 1 and the summit station No. 3 is 2.7°.

The great radiating surfaces of the mountains surrounding the Bryson region on nearly all sides serve to intensify the cooling of the lower layers of the atmosphere, thus causing during nights of inversion much lower minima at No. 3 than would be expected, considering its position at the summit of a small knob. Even so, it is then warm as compared with No. 1 on the valley floor.

The table below shows the mean monthly and annual minimum temperatures at stations Nos. 2 and 2a on the northerly and southerly slopes, respectively, for the entire four-year period, together with the differences. While the average yearly difference is only 0.6°, the monthly variation is irregular, the southerly slope averaging higher in all months with the exception of October, in which month it is 0.1° lower. In July the minimum on the southerly slope averages 1.4° higher than the station on the other slope, this being the greatest four-year average monthly difference.

Four-year average minima, Bryson, Nos. 2 and 2a, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
No. 2, N., 385 feet	32.6	28.6	29.5	41.3	49.7	56.0	59.8	59.6	53.0	44.2	33.6	27.9	43.0
No. 2a, S., 385 feet	33.1	29.0	29.8	42.4	50.6	56.8	61.2	60.6	53.3	44.1	33.7	28.2	43.6
Difference	+0.5	+0.4	+0.3	+1.1	+0.9	+0.8	+1.4	+1.0	+0.3	−0.1	+0.1	+0.3	+0.6

The relatively higher minima at No. 2a may be partly due to its southerly exposure. Prevailing wind direction is also a consideration.

During the selected periods of inversion (Table 2a) the thermal belt at Bryson is quite pronounced. In May, station No. 2a on the southerly slope, with an elevation of 385 feet, has an average mean of 7° higher than the base and 1.7° higher than station No. 2, with the same elevation on the northerly slope. The summit station, 185 feet higher up, has a mean of 13° higher than the base, and the thermal belt during these periods would doubtless be centered above the elevation of the summit station here as at Blantyre and Asheville were this slope higher up.

It will be noted that in the November period the increase in temperature with increase in elevation is not so decided as that recorded in May, and aside from the fact that the former period, as a whole, was not so favorable for large inversions as the week in May, the decreased differences between the various stations in November are due to the effect of northerly winds.

During norm conditions the variation in temperature has no special features, the decrease with elevation being approximately the amount usually observed.

Cane River (Table 2).—While the maxima at Cane River have some unusual characteristics, especially as regards the rather low readings in the cove at station No. 3 and high readings at No. 4, as shown in Tables 1 and 1a, the minima also are not entirely free from irregularities. For instance, the minimum at No. 2, on a northerly slope 190 feet above the base station No. 1, averages the higher by as much as 2.4°, but the increase in temperature above that point is very slight, the average at No. 4, the summit station, being only 3.1° more than that at the base. However, these values are, as a matter of fact, consistent when we consider that both nights of inversion and norm are involved.

The thermal conditions at Cane River during nights of inversion are quite marked, as shown by the averages for the selected periods (Table 2a), largely because of the absence of opposing slopes close by. At the summit station, No. 4, with an elevation of 1,100 feet above the base, the average excess in minimum temperature over No. 1 in May is 17.7°, with several individual differences of 20° or more, while at Nos. 2 and 3, 190 and 400 feet above the base station, the average excesses for the same month are 7.3° and 11.7°, respectively. These large differences between No. 1 and the slope stations Nos. 2 and 3 are, of course, unusual considering the elevation.

The differences between Nos. 1 and 3 are more pronounced in November than in May, and this is due to the effect of the northerly winds during the November period. As the slope at Cane River faces the north, winds from this direction, even though light, cause higher temperatures at Nos. 2 and 3.

The variation during norms is consistent with the decrease in elevation, the decrease in temperature being quite regular and much the same as on other slopes.

Ellijay (Table 2).—Here we have a group of five stations on a northerly slope ranging from the base, with an elevation of 2,240 feet above sea level, to the summit, with an elevation of 4,000 feet. This slope has been referred to previously as one more nearly approaching the ideal, as it is not broken up into coves and frost pockets, the descent being more or less regular from the summit to the base.

Of the average minimum values (Table 2) No. 4, with an elevation of 1,240 feet above the base, is the highest, the excess over No. 1 being 4.2°. No. 3 has an excess of 2.8° and No. 5, at the summit, 520 feet above No. 4, an excess of 3.3°. These, of course, represent only average conditions, and when we realize that during norm conditions the summit station invariably is considerably colder than No. 4 we must conclude that during nights of inversion the minimum at No. 5 is relatively high. As a matter of fact, while the center of the thermal belt at Ellijay is usually not far below the summit, inversions noted here are not so pronounced as those observed at Cane River.

Although the summit station, No. 5, 1,760 feet above the base, was not in operation in 1913 during the selected period of inversion in May included in Table 2a, the averages in the November period bring out clearly the thermal conditions at that level, as well as at the other stations on this slope, there being a steady increase up to No. 4, with No. 5 averaging 1.5° lower than No. 4, but nevertheless 15° higher than No. 1. As No. 4 has an average excess of 17.0° in the May period, it is probable that the thermal belt was close to the summit. In fact, sometimes during these inversion periods the temperature is highest at the summit, but it is nevertheless most frequently the highest at No. 4. This excess, 17.0° at the elevation of 1,240 feet above the base, is about the same as that at the summit station at Cane River, which has during the same period an excess of 17.7° for an elevation of 1,100 feet.

During norm conditions the temperature, of course, is steadily lower from the base to the summit, and the averages shown in Table 2a conform to the variation at other points, considering the marked differences in elevation.

Globe (Table 2).—The stations in this group are only three in number, No. 2 being 300 feet and No. 3 1,000 feet above No. 1, the base station, and because of the wide gap between the two upper stations the temperature conditions on the slope can not be clearly defined.

The average minima here (Table 2) generally increase from No. 1 to No. 3, although in the colder months of the year there is very little difference between Nos. 2 and 3, and not infrequently No. 3 is lower than No. 2.

During nights of inversion the temperature at Globe No. 2 is unusually high considering its elevation above the valley floor, 300 feet, and during the selected period, November 2–5, 1916 (Table 2a), the minimum temperature averaged 44.2°, while near by at Gorge No. 2, 290 feet above its base, the temperature averaged 33°.

The variation in minimum temperature during norm conditions needs hardly any special reference, as its rate of decrease does not seem to differ materially from that observed elsewhere.

Gorge (Table 2).—The four-year-average minima represent fairly well the differences existing between the various stations during each month. In no month during the research is the average at No. 5, the summit station, lower than that at No. 1, the base, there being a steady increase in all months from station No. 2 to the summit. The average difference between Nos. 1 and 2 is only slight, the latter in some months averaging the lower, situated as it is in a cove on a gradual slope. In December, 1914, and July, 1916, both cold and wet months and with few nights of inversion, there was practically no difference between Nos. 1 and 5.

Inversions at Gorge are exceedingly well marked, and during several of the individual months in the four-year period the minimum at No. 5 averaged from 7° to 11° above No. 1, and on some nights differences ranging from 15° to 20° were registered. An inversion of 24° was noted between Nos. 1 and 5 on May 22, 1914, and also on November 27 of the same year; and at 6 a. m. November 13, 1913, there occurred the extreme inversion of 31°. On this date the difference in the minima was but 16°, the temperature at No. 1 falling from 29° at 9 p. m. on the 12th to 26°, the minimum, at 6 a. m. of the 13th, while during this same interval the temperature at No. 5 rose from 42°, the minimum, to 57°.

Although the position of station No. 4 was changed at the close of 1914 from the north slope to a point on the northeast slope having the same elevation above the base, the average minima as compared with the base station do not vary considerably. The old station averages somewhat lower than the new one. The mean minimum temperature at the old No. 4 for the two years 1913 and 1914 is 2.8° higher than the base station, while that at the new location for the two years 1915 and 1916 is 3.4° higher than the base station, the difference in the excesses being 0.6°.

During the selected periods in May and November (Table 2a) the inversion conditions are seen to be quite pronounced at Gorge, there being a slight rise from the

base to station No. 2, and thence a rapid rise to the summit. The averages at the summit for the May and November periods were 22.2° and 18.3, respectively, higher than the base, although the difference in elevation is only 1,040 feet. This rate of increase is even greater than that at Cane River, Ellijay, or Globe for the same periods. No. 2 partakes largely of valley floor conditions, and it is nearly as cold as No. 1 during the May and November periods of inversion.

No. 3 is affected by the hills close by, not, of course, in the same degree as No. 2, but considerably, nevertheless, as indicated by the small increases at that level, 615 feet, during inversion conditions, as compared with stations at approximately the same level at other places.

It is because of the great increase in temperature at the higher levels during nights of inversion that the average minimum is relatively so high at the upper stations. In fact, the four-year-average excess in minimum temperature of 4.5° at No. 5 over the base station at Gorge, as shown in Table 2, is the greatest noted on any slope.

The decrease in temperature with elevation during norm conditions is regular and does not vary to any extent from the decrease observed on other slopes.

Hendersonville (Table 2).—The four-year averages in these tables represent fairly well the situation at Hendersonville. The differences in minima between the various stations are large considering the slight differences in elevation, and this is due to the great variation in temperature during nights of inversion.

Station No. 1, located on a nearly level surface some distance from the base of Jump Off Mountain, is a rather cold place (see fig. 13). No. 2 is on a bench or flat plot on the northeast slope of the mountain, where there is a better exchange of air on nights when the wind is from a northerly quarter than from other directions. On nights with large inversions at No. 2 the general movement of the air is from the north, and on nights when the inversions are small between Nos. 1 and 2, but large between Nos. 1 and 4, the wind is invariably from the south. Thus the barrier to the south allows the cold to accumulate at No. 2, while the greater freedom of exchange with a northerly wind retards the loss of heat. Later under the caption "Inversions" the effect of wind direction upon the temperature on this slope will be brought out in detail (see fig. 62).

During the selected periods of inversion (Table 2a) there is a pronounced increase in temperature from the base to the summit. Moreover, the increase is relatively as great in the lower as in the higher levels so far as the observations show, there being in May an excess of 7° at No. 2, with an elevation of 450 feet above the base. Again, between Nos. 2 and 4, with a difference in elevation of 300 feet, the average increase in temperature in the May period is 10.8°, while the average excess at the summit station over the base, for a difference in elevation of 750 feet, is 17.8°, both excesses being truly remarkable. In the November period the relatively large inversion at No. 2 is due to the effect of the northerly winds in favoring freedom of exchange with the warm free air, as stated above.

The differences in temperature from base to summit during norms are fairly uniform and much the same as at the other places.

Highlands (Table 2).—Here we have the highest group of stations in the entire research—in two different orchards, the Satulah and the Waldheim. The Satulah orchard, in which Nos. 1 and 2 are located, is rather warm, considering its elevation, doubtless because of its location on a southerly slope and immediately under Mount Satulah, which towers above to the north and northeast. A vast amount of heat is undoubtedly radiated from this rock to the orchard below, and No. 2, closest to the rock, naturally has the highest temperature, maximum as well as minimum.

However, the minimum at No. 2 does not average uniformly higher than No. 1, because in cloudy or wet weather the normal rate of decrease with elevation prevails. But in months having frequent nights of inversion the average at No. 2 is considerably higher than at No. 1. In the month of February, 1915, the minimum at No. 2 was frequently 10° higher than the minimum at No. 1.

The Waldheim orchard, on Dog Mountain, with somewhat higher elevation and distant a couple of miles from Mount Satulah, is much colder. The mean minimum for the four-year period at No. 3, the base station of this orchard, is 8.1° below the average at No. 1 of the Satulah orchard, and is, in fact, the lowest average of all the stations employed in this research, due to its peculiar exposure and its elevation above sea level.

The minima at No. 3 are the special feature of the Waldheim orchard, as those at Nos. 4 and 5 are not unusual, considering the elevation, nor is there generally much difference between the minima at the two higher stations. No. 3 is in a typical frost pocket in a small basin at the foot of the slope on which the orchard is located and is surrounded on all other sides by heavy timber. A relatively large area of radiating surface here permits rapid loss of heat on nights favorable for inversion, and convective exchanges are impossible.

During the selected periods (Table 2a) marked inversions are noted in both the Satulah and Waldheim orchards. The large inversions in the Waldheim orchard are due more to the very low minima observed at No. 3, its base station, than to high minima on the slope at Nos. 4 and 5. The minima at No. 3 at Highlands during the May period average 33.3°, which is 19° lower than No. 1 in the Satulah orchard, and it is not strange that a marked inversion is noted during this period at Nos. 4 and 5. At the former we have an excess over the base of 19.7° in the May and 19° in the November period for a difference in elevation of 200 feet, and this rate of increase in average minimum temperature between Nos. 3 and 4 is the greatest observed on any slope in this region during this period of inversion. For the next 200 feet, from No. 4 to No. 5, the increase in temperature is not important, so that the main feature of the thermal conditions in the Waldheim orchard is the increase from No. 3 to No. 4.

The decrease in temperature during norm conditions at Highlands conforms generally to the situation in other portions of the region.

Mount Airy (Table 2).—The group of stations at this place, having a much lower elevation than those in the main mountain region, naturally do not have so low minima during critical periods. The base station, No. 1, at Mount Airy averages the lowest of the group, as elsewhere. No. 2, on the rather steep west slope with an elevation of 160 feet above the base, shows the highest average minima—in fact, 1° higher than No. 3 on the east slope at the same elevation. This is as we would expect, because of the comparative steepness at No. 2 and its westerly exposure. A westerly exposure having the benefit of direct sunshine during the warmest period of a clear day, the free air on that slope is warmer than on the easterly side, and a station there has usually both a higher maximum and minimum temperature than an easterly slope. The summit station, No. 4, 200 feet higher up on the ridge and located between Nos. 2 and 3,

has an average minimum midway between the two on the slope.

The table below gives the average monthly and annual minimum temperatures for Nos. 2 and 3, on the west and east slopes at the same elevation, with the differences between the two. While No. 3 averages 1° lower for the entire four years, there are some months in which the differences are much greater, the greatest being 2° in November, which month, along with May and October, is characterized by a large number of inversions. The months with few inversions and cloudy weather, January, February, March, and December, have only small differences between Nos. 2 and 3.

Four-year average minima, Mount Airy, Nos. 2 and 3, including direction of slope and elevation above the base.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
No. 2, W., 160 feet	34.3	31.4	35.6	47.2	57.2	63.1	66.3	64.7	58.8	51.3	41.0	32.2	48.6
No. 3, E., 160 feet	34.0	30.8	35.3	46.4	55.6	61.8	64.7	64.0	57.6	49.7	39.0	31.8	47.6
Difference	−0.3	−0.6	−0.3	−0.8	−1.6	−1.3	−1.6	−0.7	−1.2	−1.6	−2.0	−0.4	−1.0

The mean minima during the selected periods of inversion (Table 2a) indicate that the thermal conditions at Mount Airy are most unusual, especially at No. 2 at the 160-foot level on the west slope, where there was an average excess in minimum temperature over the base of 12.2° in the May period, thus emphasizing the effect upon the minimum temperature during nights of inversion of a westerly location and a steep slope. This difference is much greater than that noted in the same periods between Nos. 2 and 2a, Asheville, which have a corresponding elevation above the base station, but not so great as noted at Transon No. 2, somewhat similarly situated as regards its base station. The summit station No. 4 at Mount Airy, 200 feet above No. 2, has an average excess of 13.5° over the base station. This in itself is exceptionally large, but the principal feature is the excess at No. 2. The figures in the November period follow closely those in May as far as variation is concerned, although the actual values are lower, as should be expected.

The conditions prevalent at Mount Airy during the norm period, as shown by Table 2a, are somewhat abnormal, the average rate of decrease in minima between base and summit being 2.2° for 300 feet.

Transon (Table 2).—The group here has a considerable altitude above sea level, but with only slight differences between the various stations. Moreover, the slope is gentle and not steadily upward, there being two or three knolls and corresponding depressions, as shown by the profile in Figure 37.

The four-year averages in minimum temperature are fairly representative of the variations throughout the different months of the year, although in the colder months there is little difference between Nos. 3 and 4. However, No. 1 is always the coldest, as in no month during the entire four years does any other station here average lower.

During the selected periods of inversion (Table 2a) the increase in temperature on the slope is most marked; in fact, considering the slight differences in elevation between the various stations, the average inversion during the May period is one of the greatest observed during the research, and this applies especially to the large difference of 14.2° between the base station, No. 1 and No. 2 on the west slope, 150 feet higher up. While this difference is not so large as that observed between the two lower stations in the Waldheim orchard at Highlands, the excess is greater than that noted at No. 2, Mount Airy, somewhat similarly situated, and it is more than twice as great as that between Nos. 1 and 2 at Wilkesboro, which have the same difference in elevation, although the No. 2 station there is on a north slope instead of a west slope, as at Transon.

During norm conditions the rate of decrease in temperature from the base to summit at Transon is apparently close to the average for the region.

Tryon (Table 2).—While the base station at Tryon has the least altitude above sea level of all employed in the research, 950 feet, No. 4 is 1,100 feet above on Warrior Mountain, so that on this slope there is a considerable range in elevation.

The mean minimum temperature decreases regularly from No. 2 to No. 4, there being no month in the four years in which No. 3 is not lower than No. 2 and in which No. 4 is not lower than No. 3. In this respect Tryon differs from all the other groups of stations, except possibly Altapass. However, the average for the four years at each of the three higher stations at Tryon is higher than at No. 1, although in steadily decreasing amounts from No. 2 upward.

The conditions at Tryon, with a high plateau overlooking the Pacolet valley, are ideal for the development of the mountain breeze at night, and an examination of the trace sheets at No. 1, on the valley floor, shows this to be the case during periods of anticyclonic weather. The strength of the breeze is either aided or impeded according to the direction and speed of the general air movement.

The increase in temperature during the selected May period of inversion (Table 2a) was quite marked from the base to No. 2 station, 380 feet above with an average excess of 14.4°, but, of course, this rate of increase does not compare with the increase at the lower levels of the slope at Highlands, Transon, or Mount Airy. During the November period the inversions were not so large as those found in the spring, and this was largely due to the prevalence of the mountain breeze during the former period, which prevents the temperature at No. 1 from reaching a low point.

During norm conditions at Tryon (Table 2a) the average rate of decrease in minimum temperature is about normal between Nos. 1 and 2, while the decrease between Nos. 1 and 4 is 1.4° for each 300 feet, or slightly in excess of the normal rate in this region. Between Nos. 2 and 3 there is a decrease at the rate of 2.5° for 300 feet. It is not understood why there should be the great difference in minimum temperature between these two stations located only a short distance from each other, and it is probable that a part of the difference is due to instrumental errors that were not detected during the period of the observations, although every precaution was taken to check the readings and correct all errors.

Wilkesboro (Table 2).—This group, like Mount Airy, having a low altitude, with the slope ranging in elevation from 1,240 feet to 1,670 feet above sea level, also has minimum temperatures relatively high.

No. 1 is a cold station during inversion weather and, although not on a valley floor, is located on a bench or nearly level portion of the slope. The exposure at No. 2 is better, and that station is free from frost during critical periods. During inversion weather the differences between Nos. 1, 2, 3, and 4 are greater with high pressure north of the station than when it is to the south. The

barrier of the Brushy Mountains cuts off any flow of light southerly wind and allows the cold air to accumulate on the comparatively level portions of the slope.

Nos. 3 and 4 are quite warm, No. 3 being on a small knob and No. 4 on the crest of a small ridge, averaging for the four-year period, respectively, 3.5° and 3.6° above No. 1. These figures exceed the four-year average differences recorded even at Bryson, Globe, and Blantyre and compare with those at Hendersonville for the same period.

During the selected periods of inversion (Table 2a) the increase in temperature with elevation at Wilkesboro is quite pronounced, although not so marked as on the west slope at Mount Airy. The effect of northerly winds during the November period is markedly shown in the large amounts of inversions, Nos. 3 and 4 averaging 14° and 15.4°, respectively, higher than No. 1. Wilkesboro is the only point in the research where the inversions were greater in the November than in the May period, as is evident from an inspection of Table 2a. The range of inversion here in the November period is in harmony with the four-year average differences in minimum temperature and even exceeds those observed at Bryson, Globe, and Blantyre.

The difference in elevation between the Wilkesboro stations is only slight, so that during norm conditions there is naturally not much variation in temperature, as shown by Table 2a.

Variation in minimum temperature during periods of inversion in spring and autumn.—Figures 47 and 48 strikingly illustrate the variation in minimum temperature in the region as a whole during the selected periods of inversion in spring and autumn, the data for which are given in detail in Table 2a.

In both May and November periods the nights were clear, with calm air or light south to southeast winds in the former and light to gentle northwest winds in the latter.

At a glance one may determine the character of the exposure of the stations having approximately similar elevation, or, at least, whether they are valley-floor stations on the one hand or slope and summit stations on the other.

For instance, note the high temperature during both these periods at Tryon No. 2 on a slope as compared with the valley-floor stations having approximately the same elevation, and especially with that at Gorge No. 1, the latter registering 21.7° lower in the spring period and 19.3° lower in the autumn period than the Tryon station.

Then we may compare the summit station, Tryon No. 4, with the cold base station at Blantyre, where we find in the spring period a difference of 23.2° and in the autumn the smaller difference of 14.5°.

There are also large differences apparent in the two periods between the summit station at Gorge and the valley floor station at Asheville, both having about the same elevation, and between the summit station at Globe and the valley-floor station at Cane River.

There are the unusually large differences between the minima on the valley floor in the Waldheim orchard at Highlands, station No. 3, and several other stations with approximately the same elevation, the base station at Highlands in practically every case being 20° or more lower than any of the slope or summit stations. In the spring period the difference between the minimum in the Highlands frost pocket and the summit station at Cane River was 23.4° and in the autumn 21.0°.

The figures also furnish some light on the relative exposures of the base stations. Thus, compare the readings at the base station at Gorge with that at Mount Airy, the former being much colder, as it is in a frost pocket.

Compare the base stations at Bryson, Blantyre, Hendersonville, Ellijay, and Altapass, the first two named being the coldest because they are located in wide frost pockets. Ellijay No. 1 is not so cold, because free radiation on that valley floor is obstructed by the towering mountains on both sides. Station No. 1 at Altapass is, of course, much warmer, because of its location on a slope.

The valley-floor characteristics of the slope stations, No. 2, at Gorge and Blantyre, are also brought out by this comparison, the minima at these two stations averaging much lower than at the other stations on slopes or summits having approximately the same elevation. In fact, Blantyre No. 2 averages lower than Asheville No. 1 during inversions.

It is also evident from the figures that the No. 1 stations at Blowing Rock and Highlands are not valley-floor stations, but rather located on slopes where the minima during inversions are quite high.

Moreover, the data in Figures 47 and 48 furnish a basis for comparison between the summit stations. Station No. 5 at Gorge and No. 3 at Globe, with their relatively high minima, stand out as rather warm; also Cane River summit station, No. 4.

The high minima at the summit stations of Gorge and Globe are in strong contrast to the low minima at the summit station at Bryson No. 3. The stations in the Bryson group differ only slightly in elevation, and, while marked inversions occur there, the section as a whole is in a wide frost pocket with surrounding mountains at great elevation. The center of the thermal belt at Bryson would be at a much higher elevation were the slope of greater altitude.

The minima are shown to be low on the summit at Altapass, station No. 5, because of the great surface area surrounding it during inversions, as compared with other summits and with other slopes of approximately the same or even higher elevation. Altapass is on an elevated plateau on the main Blue Ridge with opportunity for free radiation at station No. 5, and the loss of heat through radiation from this large mass is large as compared with that received by interchange with the free air.

The differences between the minima at this summit station in the selected spring and autumn periods of inversion and the other summit stations of higher elevation, such as Ellijay, Cane River, Transon, and Highlands, are striking, Altapass registering from 5° to 7° lower, although normally, because of lower elevation alone, it should read higher. The knobs upon which these other summit stations are located being small, partake of the temperature of the surrounding warm free air. The effect of summit area upon night minima is brought out strongly in this comparison.

The summit area at the highest station at Blowing Rock is also considerable, but not so great as at Altapass, and we find here that during the selected periods of inversion station No. 5 at Blowing Rock averages about 3° lower than station No. 5 at Highlands.

So the summit station at Tryon No 4 in the November period has a low minimum as compared with many summit and slope stations higher up during the prevalence of light northwest winds, when the effect of loss of heat through radiation from the high plateau is pronounced, and this difference exists in spite of the fact that Tryon has one of the most southerly positions. In the May

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period, with prevailing south to southeast winds, the temperature on the Tryon summit was not so low.

Rate of increase or decrease in average monthly and annual minimum temperature on six selected long slopes.—Table 2b contains a comparison of the mean monthly and annual minimum temperatures for the lowest and the highest stations on the six longest slopes having a difference in elevation of 1,000 feet or more, after the plan of Table 1b, which gives a comparison of the mean maximum temperature. This table will supplement the tables of other minimum temperature data which have just been discussed.

Because of the influence of inversions the average minimum temperature for the four years is lowest at the base stations of five of the six slopes. Altapass is the only one of the six that has a lower average minimum at the summit than at its No. 1 station, and this condition is persistent throughout all months. However, if Altapass No. 1 were located on a valley floor, the observations on that slope might show much the same relation as those noted on the other slopes, with the base station averaging the lower, although this might not be so, as the summit at Altapass, because of the great summit area surrounding, has comparatively low minima, as we have already seen.

The four-year average for March at the base station at Cane River is slightly higher than that at the summit, and this relation is true also at Tryon from June to October, inclusive. At the latter place in December there is no difference between the averages at the base and summit stations, nor at Ellijay in March; otherwise the averages at the base stations are lower than those at the summit. At Tryon the small increase in average minima between the base and summit is not indicative of either the frequency or amount of inversion, as the point of highest minima on this slope lies between the two at an unusually low altitude, 400 to 500 feet above the valley floor.

Of all these selected slopes the greatest rate of increase in annual average minimum temperature between the base and summit stations is at Gorge, 1° for 231 feet, the average minimum at No. 5 at this point exceeding that at No. 1 by 4.5°. The rate of increase in minimum temperature would naturally be the greatest on the slope having the largest inversions for the least difference in altitude between base and summit, and this relation, as brought out later in the discussion of "Inversions," is most marked at Gorge. The slopes at Cane River and Globe have rates of increase amounting to 1° for 355 and 357 feet, respectively, while Ellijay, with about the same difference in average minima between its summit and base stations as Cane River and Globe, has actually a smaller rate of increase, doubtless because of the greater length of its slope.

Excepting Altapass, the greatest average monthly rate of increase on all the slopes occurs in the spring and autumn, usually in May and November, when inversions are most pronounced. Even at Altapass the tendency to less pronounced norms in May, October, and November is shown by the rate of decrease in average minima during those months.

This table brings out strongly the great preponderance of inversion over norm conditions.

TABLE 2b.—*Monthly and annual average minimum temperatures on the six long slopes, showing rate of increase or decrease with elevation, 1913–1916.*

[The slopes selected for this comparison have a difference in elevation of 1,000 feet or more between the base and summit station. The difference in temperature between the base and summit stations on each slope is given, as well as the difference in feet for each degree difference in temperature.]

Slopes and stations.	Elevation.[1]		January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.	Annual.
	Base.	Summit.													
	Feet.	*Feet.*													
Altapass No. 1	2,230		31.1	29.1	31.5	44.2	52.8	58.4	60.5	61.3	54.0	46.3	36.6	29.8	44.8
Altapass No. 5		1,000	29.1	27.0	28.8	42.1	51.0	55.8	60.2	59.5	52.5	45.2	35.4	27.4	42.9
Difference			−2.0	−2.1	−2.7	−2.1	−1.8	−2.6	−2.3	−1.8	−1.5	−1.1	−1.2	−2.4	−1.9
Feet for 1° difference			500	476	370	476	556	385	435	556	667	909	833	417	526
Cane River No. 1	2,650		26.4	25.7	27.2	37.6	46.6	53.9	58.1	58.0	49.6	40.4	28.5	24.8	39.7
Cane River No. 4		1,100	28.8	26.9	27.1	41.0	51.3	56.7	60.2	59.6	53.1	45.3	36.3	27.2	42.8
Difference			+2.4	+1.2	−0.1	+3.4	+4.7	+2.8	+2.1	+1.6	+3.5	+4.9	+7.8	+2.4	+3.1
Feet for 1° difference			458	917	[2] 11,000	324	234	393	524	688	314	224	141	458	355
Ellijay No. 1	2,240		30.2	27.7	28.6	39.7	48.2	54.7	58.8	58.4	51.1	42.5	31.1	27.4	41.6
Ellijay No. 5		1,760	32.6	29.6	28.6	44.2	54.0	58.4	60.9	60.0	54.7	48.1	37.7	28.6	44.9
Difference			+2.4	+1.9	0	+4.5	+5.8	+3.7	+2.1	+1.6	+3.6	+5.6	+6.6	+1.2	+3.3
Feet for 1° difference			733	926	0	391	303	476	838	1,100	489	314	267	1,467	533
Globe No. 1	1,625		31.8	29.0	32.4	41.9	51.1	58.0	62.0	61.6	54.6	46.5	34.6	29.2	44.4
Globe No. 3		1,000	33.6	30.4	33.5	46.0	55.9	61.2	64.6	63.5	57.2	49.7	39.8	30.8	47.2
Difference			+1.8	+1.4	+1.4	+4.1	+4.8	+3.2	+2.6	+1.9	+2.6	+3.2	+5.2	+1.6	+2.8
Feet for 1° difference			556	714	714	244	208	312	385	526	385	312	192	625	357
Gorge No. 1	1,400		30.8	28.1	32.3	40.5	49.3	56.8	61.1	61.0	53.9	45.2	32.8	27.9	43.3
Gorge No. 5		1,040	33.5	30.9	34.4	46.9	57.0	61.4	64.9	63.7	57.7	49.9	41.1	32.0	47.8
Difference			+2.7	+2.8	+2.1	+6.4	+7.7	+4.6	+3.8	+2.7	+3.8	+4.7	+8.3	+4.1	+4.5
Feet for 1° difference			385	371	495	162	135	226	274	385	274	221	125	254	231
Tryon No. 1	950		34.7	32.3	35.9	44.7	54.8	63.0	66.7	66.3	58.5	50.6	37.3	32.8	48.1
Tryon No. 4		1,100	35.8	33.3	36.2	47.5	56.9	61.9	65.0	64.4	58.0	47.7	40.6	32.8	48.8
Difference			+1.1	+1.0	+0.3	+2.8	+2.1	−1.1	−1.7	−1.9	−0.5	−2.9	+3.3	0	+0.7
Feet for 1° difference			1,000	1,100	3,667	393	524	1,000	647	579	2,200	379	333	0	1,571

[1] Base station above sea level; summit above base.
[2] The datum "Feet for 1° difference" obviously fails of any physical significance when the temperature differences between slope stations are quite small.—ED.

Monthly and average annual minima at the two stations having, respectively, the highest and lowest elevations.—In comparing the mean minima at the station having the lowest altitude, Tryon No. 1, a valley-floor station, with the most elevated station, Highlands No. 5, located a short distance below the summit of Dog Mountain, with a difference in elevation of 3,125 feet (Table 2c), we find that the Highlands station averages the lower throughout all the months of the year, with an average difference of 5.6°, the greatest difference, 10.5°, being in March, when norms are most frequent, and the least, 0.5°, in November, a month marked by frequent inversions. The average decrease for the entire four-year period amounts to 1° for 558 feet.

TABLE 2c.—*Average monthly and annual minimum temperatures at the two stations having, respectively, the highest and lowest elevations, showing rate of decrease with elevation, 1913–1916.*

	Elevation.	January.	February.	March.	April.	May.	June.
	Feet.						
Tryon No. 1	950	34.7	32.3	35.9	44.7	54.8	63.0
Highlands No. 5	4,075	28.6	25.7	25.4	41.5	51.4	56.5
Difference		−6.1	−6.6	−10.5	−3.2	−3.4	−6.5
Feet for 1° difference		512	473	298	977	919	481

	Elevation.	July.	August.	September.	October.	November.	December.	Annual.
	Feet.							
Tryon No. 1	950	66.7	66.3	58.5	50.6	37.3	32.3	48.1
Highlands No. 5	4,075	59.8	58.7	52.6	46.0	36.8	28.6	42.5
Difference		−6.9	−7.6	−5.9	−4.6	−0.5	−3.7	−5.6
Feet for 1° difference		453	411	530	679	6,250	840	558

NORMS.

The graph, Figure 49, illustrates the variation in average minimum temperature on the selected dates in January, February, and March, 1916, during norm conditions, the data for which are given in detail in Table 2a.

In considering this graph we should make due allowance for latitude, and the figures might be reduced to the parallel of 35°, approximately the position of Highlands, by using corrections, the largest of which would be 3° for Mount Airy, located in the extreme north, the correction for the other stations lying between that amount and zero. The lowest average minimum during this period is 8.8°, at Blowing Rock No. 5, one of the most elevated stations and one of the most northerly, while the other summit stations having a greater altitude, Ellijay and Highlands, have considerably higher minima, 11.5° and 10.6°, respectively; but if due correction were made for difference in latitude the excesses at the more southerly stations, Ellijay and Highlands, would be largely offset.

On the selected nights there seems to be a general decrease in temperature with elevation from the lowest station at Tryon to these high-level stations, but this decrease is not uniform, mainly because of difference in latitude and in some cases because of difference in topography and slight influences of inversion. In this respect Figure 49 furnishes data in strong contrast with Figures 47 and 48, which present mean minimum temperatures for the various stations during the two selected periods of inversion weather. While topography has little effect upon the minimum temperature during norm conditions as compared with inversion, its influence is nevertheless apparent. We find by referring to Figure 49, that almost invariably, of the stations having the same elevation base stations register the lowest and upper stations the highest minima. There is no question that during clear weather at night, even with strong winds from the northwest, surface area is a factor in increasing the loss of heat through radiation from the ground, provided it is colder than the free air, and this study shows that in the mountain region there is always a tendency toward inversion, with a consequent lowering of temperature on the valley floors. This effect, however, was largely neutralized on these dates selected, as the weather was mostly windy, and thus the average decrease in minimum with elevation in the region approximates closely the adiabatic rate.

Comparing the mean minima for the days selected at the lowest and highest stations in the region—Tryon No. 1, a base station with an elevation of 950 feet above sea level and an average minimum of 25.7°, and Highlands No. 5, a summit station with an elevation of 4,075 feet and an average minimum of 10.6°—we find a difference in temperature of 15.1°, or a rate of decrease with elevation of 1.4° for 300 feet.

Moreover, the mean minimum for the whole region shows an average decrease in temperature for elevation of about 1.5° for each 300 feet of ascent. Individual dates at Ellijay show rates as much as 1.9° per 300 feet, which are superadiabatic. With falling temperature over an entire slope, as in the approach of a general cold wave, it is evident that there is a strong overrunning at the more elevated stations, and the vertical temperature gradient then becomes strongly superadiabatic.

At Bryson and Ellijay, which are in the extreme western part of the region, clear weather prevailed in the early morning on two, and possibly three, of the dates used in the table, allowing a slight inversion between the two lower stations, which reduced somewhat the average differences on these slopes. Thus at Ellijay we have an average difference of only 0.6° for the first 300 feet, compared with the rate of 1.2° per 300 feet for the entire slope. On the Altapass slope during this period the rate of decrease was about 1.5° for each 300 feet of elevation, 1.4° at Tryon, and 1.5° at Cane River. The norm condition was ideal at Globe on all the dates selected, and here we find an average decrease of 1.7° for each 300 feet.

In comparing the Waldheim orchard stations, Nos. 3, 4, and 5, with the Satulah orchard, stations Nos. 1 and 2 at Highlands, the protective influence of Mount Satulah seems to be evidenced by the higher temperature in the latter.

At Asheville stations Nos. 2 and 3, which face the full force of the northerly winds, seem invariably to have a lower minimum temperature during norm conditions than Nos. 2a and 3a, which are protected somewhat by a steep ridge running east and west. The cold air evidently sweeps over the ridge, striking Nos. 2 and 3 directly and reaching the other stations only by a back flow or eddy. Thus with a lowering temperature there is a continual delay of the minimum temperature at Nos. 2a and 3a, until finally, after daybreak, the temperature begins to rise at all stations, although much earlier at Nos. 2a and 3a, if the sun is shining.

Under norm conditions we would expect the temperature decrease to be approximately normal because the air is relatively dry and at the various elevations is mixed and in equilibrium. Ordinarily during a fall in temperature the thermograph traces on any long slope are found in parallel lines, or approximately so, and this condition is well illustrated by Figure 69, which shows the thermograph traces during a typical cold wave, March 2–4, 1916, on the slopes of Ellijay and Altapass.

The effect of decrease in temperature with elevation is strikingly shown in Figure 49, and this is a most important factor in the growing of fruit in the Carolina mountain region. While frost may at times during inversion conditions be damaging on valley floors, it is the cold of elevation during norm conditions that causes the greatest injury. We will see later as we proceed in the discussion that the length of the growing season depends largely upon the altitude, and reasons will be given why successful fruit growing is not found at the higher levels of this region.

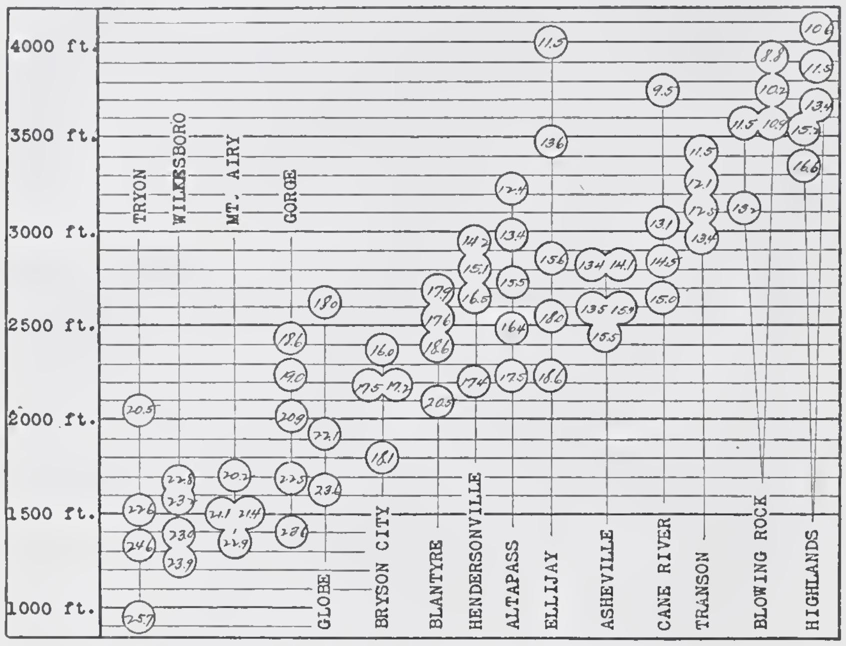

FIG. 49.—Average daily minima during eight selected norm nights in January, February, and March, 1916; stations grouped according to elevation above sea level.

ABSOLUTE MAXIMUM AND ABSOLUTE MINIMUM TEMPERATURES.

In connection with fruit growing, the absolute maxima and absolute minima doubtless are just as important as the average maxima and average minima, the extremes indicating the limits within which the temperatures lie, operating toward safety or injury. The absolute minima are especially important. Table 3 gives the absolute maxima, the absolute minima, and the absolute ranges in temperature at the different stations for the four years of the research. This table supplements previous ones and contains material that should be useful for study purposes. It hardly seems advisable to go into a discussion of the data in great detail, but reference will be made to the more important features.

The highest absolute maximum in the entire region, 103°, occurred July 19, 1913, at the Tryon lower-level stations, Nos. 1 and 2, and the other stations at which 100° was reached or exceeded, Gorge Nos. 1 and 5, Mount Airy No. 1, Tryon Nos. 3 and 4, and Wilkesboro Nos. 1, 2, 3, and 4, were in no case above the 2,100-foot level, except Gorge No. 5, which has an elevation of 2,440 feet. Maxima as high as 100° were registered in only two of the four years, 1913 and 1914. There was a general decrease from the 100° mark downward through the 90's, every station registering a maximum of 90° or over in one or more summers, except Nos. 2, 3, 4, and 5 at Blowing Rock and Nos. 3, 4, and 5 at Highlands, all above the 3,500-foot level in the two most elevated groups. Of these seven stations, Blowing Rock Nos. 2, 3, and 5 and Highlands Nos. 3 and 4 had a four-year absolute maximum of 88°, the other two having one of 89°. Thus we have for the four-year period an extreme variation of 15°, from 103° to 88°, in the absolute maxima in this region, with stations ranging in elevation from 950 feet at Tryon to 4,075 feet at Highlands. At the latter elevation, Highlands No. 5, however, the absolute maximum was 89°, 1° in excess of the lowest absolute maximum, 88°, registered at certain stations of lower altitude at both Highlands and Blowing Rock named above.

As already stated, a maximum of 100° in this mountain region is not reached every year by any means, even at Tryon, where the highest readings in 1915 and 1916 were 99° and 97°, respectively. Moreover, 90° is not registered each year on an average at any one of the Blowing Rock or Highlands stations, their highest annual readings usually being considerably below that mark. In 1916 the absolute maxima at Blowing Rock ranged from 85° to 81° and at Highlands from 87° to 85°, the low reading of 81° at Blowing Rock being registered on June 30, at station No. 5, 3,930 feet above sea level. In spite of the elevation, 81° seems to be an exceedingly low maximum temperature for an entire year. It is the lowest summer maximum registered during the period of the research. Both Blowing Rock and Highlands are located on elevated plateaus, the former close to the Tennessee border on the north and the latter only a few miles from the Georgia border on the south, as shown by the relief map. At Highlands ideal summer-resort weather prevails during the heated season, though its latitude is only about 35° N. The summer temperature is even lower at Blowing Rock, located far to the north.

Station No. 3 at Highlands, with an elevation of 3,675 feet, has the lowest minimum during the four-year period, −7° on December 15, 1914, and in no other year did the temperature at any one of the Highlands stations fall below zero. No. 3, at which this low minimum occurred, is in the frost pocket so often referred to in this discussion, where the lowest average minima in the entire region are also observed (see Table 2). Highlands Nos. 4 and 5 recorded a minimum of −2° on March 2, 1914. The absolute minimum at Blowing Rock was −5° at No. 5, 3,930 feet above sea level, on December 15, 1914, the same date on which the absolute minimum of −7° was registered at Highlands No. 3.

The lowest minimum, considering the elevation, was −6° at Blantyre No. 1, elevation 2,090 feet, observed also on December 15, 1914. It has been stated previously that the average minima also at Blantyre are relatively low, because of the low night temperatures there during nights of inversion. The valley of the French Broad, where Blantyre is located, is rather wide with gentle grade, and this condition, together with the surrounding mountains in the distance, forms an extensive frost pocket, favoring the occurrence of abnormally low minima during inversion conditions.

The Bryson region is somewhat similar topographically, and the average minima at both places are low during inversion conditions, but, nevertheless, at none of the Bryson stations was an absolute minimum of zero recorded during the entire four-year period, the lowest being 1° above zero on December 15, 1914, at the summit station, No. 3.

The Tryon stations, at which high maxima are observed, have relatively high minima also, the lowest, 7°, being recorded at both Nos. 1 and 4, at the former, December 20, 1916, and at the latter, December 15, 1914. Nos. 2 and 3 have minima of 12° and 10°, respectively, and these are the highest absolute minima noted in the entire region during the period of the research.

So the highest absolute maxima and minima are registered at stations in the Tryon group, the lowest in elevation, just as the lowest absolute maxima and

minima are observed in the most elevated groups, Blowing Rock and Highlands. While the highest maxima occur in July and August, the lowest minima during the four-year period do not, as a rule, occur in January and February, as would ordinarily be expected. The lowest mark was reached at most of the stations during the cold spell from December 14–16, 1914. In fact, there is not a single group in which the absolute minimum is not registered at least at one station during that period. At the two upper stations at Ellijay, Nos. 4 and 5, and at Highlands, Nos. 1, 2, 4, and 5, the lowest temperature was recorded March 2, 1914, and at Blowing Rock Nos. 3 and 4, Mount Airy No. 1, and Wilkesboro No. 2, on January 18, 1916.

At no station was the absolute minimum registered in the month of February, although the average minima at all stations were considerably lower in February than in January. The same may be said regarding the maxima, but this is because there were two warm Januaries—1913 amd 1916—and not because January is normally warmer than February.

The figures that impress one most in this discussion are not the absolute maxima, but rather the absolute minima. The absolute maxima are usually about what should be expected when the elevation of the region is considered, but one is rather surprised that the absolute minima are not lower and the winter cold is not more severe. In fact, the minima are relatively high during the colder months of the year, doubtless because in the winter there occur frequent periods of precipitation with high relative humidity and considerable cloudiness. The area of high pressure off the Carolina coast during that season is ordinarily not persistent, and inversions of temperature are infrequent. Consequently low minima are due then almost entirely to the cold brought from the regions farther west, but the cold waves in their eastward and southeastward course moderate steadily, the HIGHS passing quickly across the region, followed usually by an immediate rise in temperature. Thus the minima in the winter occur nearly always under warm conditions and not in periods of inversion.

Both the absolute and average maxima, as well as the absolute and average minima, in the mountain region, are comparatively high during the colder months, and periods of high temperature often prevail sufficiently long to promote plant growth.

The minimum temperatures during the summer months as compared with the winter minima are quite low, especially at the base stations. At the five Blowing Rock stations during the four-year period the minima in the month of June ranged from 33° to 38°, in July from 39° to 47°, and in August from 44° to 53°. At the five Highlands stations the minima in June ranged from 32° to 39°, and in July and August from 36° to 52° and from 36° to 51°, respectively. The lowest June minimum at Highlands, 32°, was registered at No. 3 on June 10, 1916, and also on June 13 and 14, 1913, this being the base station of the Waldheim orchard, called the frost pocket, while the June minimum of 33° was recorded at Blowing Rock No. 3, the base station of the Flat Top orchard, June 11, 1913. On June 13 and 14, 1913, the dates on which minima of 32° were recorded at Highlands No. 3, the readings at Blowing Rock No. 3 were, respectively, 39° and 58°. The remarkable difference of 26° on the 14th between the two No. 3 stations at Highlands and Blowing Rock was due entirely to the influence of the mountain breeze at Blowing Rock, which prevented the temperature at its base station from falling to a low point.

No mountain breeze is ever observed at Highlands No. 3 station, which is situated in a slight depression with no outlet at the base of a slope surmounted by a small knob and surrounded by timber on the other sides, with comparatively level country beyond, so that there is no opportunity for the development of a mountain breeze in that locality. However, the plateau at Blowing Rock, on which the summit station, No. 5, stands, has considerable surface area, and there is an outlet to the southeast and south from the valley floor where No. 3 is located, with a steep descent beyond, the position being especially favorable for a descending breeze when the wind is from the north. These variations in topographical conditions are often responsible for great differences in minimum temperature between the two places, and while the Blowing Rock station usually has low minima during nights of inversion the nocturnal fall in temperature is often retarded because of the breeze down the slope from Flat Top.

During the spring rather low minima are observed at Transon, Blowing Rock, and Highlands, the more elevated places. In April the absolute minima are far below freezing. Moreover, in May, at Transon station No. 1, a minimum of 25° was registered in 1913 on the 11th. Also on the same date the absolute May minimum of 23° was registered at Blowing Rock No. 3 and one of 27° at Highlands No. 3 on May 10, 1914. Other places having minima below freezing during May are Gorge No. 2, with a record of 29° May 11, 1913; Cane River, on the same date, with a record of 30° at station No. 1; and both Bryson and Blantyre when 31° was registered at the base stations on May 12, 1913, and May 19 and 20, 1914, respectively. All these low minima were registered at the stations that have been shown to be notably cold during inversion conditions and where the average annual and monthly minima are low.

Transon No. 1 and Highlands No. 3 are the only stations where freezing temperature was observed during any June in the four-year period. A minimum of 31° was registered at the former on June 11, 1913, while readings of 32° were registered at Highlands on three days in June during the three-year period. The temperature at the colder station at Blowing Rock, No. 3, did not fall quite to freezing in June, probably because of the influence of the nocturnal breeze down the slope.

Comparatively low temperatures are registered at these three places, not only in the spring and summer, but also in the autumn. In practically every September the temperature falls to freezing or below at stations No. 3 at both Blowing Rock and Highlands and at No. 1 at Transon, and 25° was registered at the Highlands station on September 23, 1913. The lowest at Blowing Rock was 30° on the same date.

The lowest temperatures registered in October in the four-year research were 12° at Highlands and 19° at Blowing Rock in 1914 on the 28th. These represent, of course, the conditions in the frost pockets at both places. The autumn minima at the other stations on these two slopes are considerably higher, especially at Highlands. For instance, the lowest temperature in September at any slope station at Highlands during the four-year period was 35° and in October 20°. In any case, the temperatures in the spring and autumn are usually sufficiently low at these higher altitudes to limit the growing season to a period too short for the satisfactory maturing of fruit.

At Bryson and Blantyre, also, low minima are observed in the autumn, freezing temperature usually occurring at the base stations in both places in September. During the four-year period the lowest minimum in this month was 31° at Blantyre and 32° at Bryson. In October, moreover, the minima at these two places are even lower than those at Blowing Rock, but not so low as those in the frost pocket at Highlands.

Tryon, because of its low altitude, does not seem to experience any critical temperatures during September, and it is not until late in October, after harvesting of the fruit, that the freezing point is reached. In October minima considerably below freezing occur throughout the whole mountain region with the exception of Tryon, the absolute minima that month at the four stations during the four years of the research being only slightly below freezing.

The lowest minima, of course, are at the bases of the respective slopes, while the orchards, as a rule, are on the slopes above, where much higher minima are observed during frosty nights.

One is impressed with the low minima in these mountain sections during the spring, summer, and autumn months, especially at the higher levels. Freezing temperature is quite common during the month of April and at the higher elevations and in frost pockets in May, and occasionally even in June, while in the summer months temperatures below 40° occur frequently in the colder places. In the autumn in the more elevated sections freezing temperatures invariably occur during the latter part of September, and by October minima below freezing are observed in practically all sections of the region. On the other hand, relatively high maxima, as a rule, are observed for protracted periods during the winter and early spring, as high as 60° to 70° or more in January and February and 70° to 80° in March. These unusual conditions result in the early opening of buds and are often followed by damaging temperatures. This feature of the temperature conditions in the mountain region will be discussed in extenso later in connection with the discussion of "Hour-degrees of frost," the occurrence of frost and freezing temperatures, and the length of the growing season.

The absolute maxima and absolute minima in each group occur, as a rule, at the stations where the highest average maxima and lowest average minima, respectively, are recorded, and in the large majority of cases the absolute maxima, the highest average maxima, the absolute minima, and the lowest average minima are observed at the base stations. Absolute minima recorded at the summit occur during norm conditions and those at the base stations during nights of inversion.

TABLE 3.—*Annual maximum and minimum temperatures and range for the years of observation (on the left) and absolute maximum and minimum for the period (on the right).*

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations; elevation of base stations above mean sea level (feet).	Height of slope stations above base (feet).	1913			1914			1915			1916			1913–1916.			Dates of absolute maxima.	Dates of absolute minims.
		Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.		
Altapass:																		
No. 1, base station, elevation 2,230	....	95	16	79	95	3	92	96	16	80	90	9	81	96	3	93	July 31, 1915	Dec. 16, 1914.
No. 2, SE	250	96	14	82	95	5	90	93	15	78	91	8	83	96	5	91	July 19, 1913	Dec. 15, 1914.
No. 3, SE	500	92	14	78	93	4	89	90	15	75	86	8	78	92	4	88	....do	Mar. 2, 1914.
No. 4, SE	750	92	12	80	92	2	90	90	13	77	86	4	82	92	2	90	....do	Dec. 15, 1914.
No. 5, summit	1,000	92	10	82	91	0	91	92	12	80	86	4	82	92	0	92	July 19, 1913; July 31, 1915.	Dec. 15, 16, 1914.
Asheville:																		
No. 1, base station, elevation 2,445	....	94	10	84	92	3	89	90	15	75	89	4	85	94	3	91	July 19, 1913	Dec. 15, 1914.
No. 2, N	155	94	11	83	92	2	90	90	15	75	87	3	84	94	2	92	....do	Do.
No. 2a, S	155	93	11	82	91	3	88	89	15	74	88	5	83	93	3	90	....do	Do.
No. 3, N	380	91	11	80	90	2	88	85	13	72	83	5	78	91	2	89	....do	Do.
No. 3a, S	380	96	11	85	95	3	92	94	14	80	90	5	85	96	3	93	....do	Do.
Blantyre:																		
No. 1, base station, elevation 2,090	....	98	9	89	94	−6	100	91	12	79	93	−3	96	98	−6	104	....do	Do.
No. 2, NW	300	98	10	88	93	−3	96	90	13	77	92	0	92	98	−3	101	....do	Do.
No. 3, NW	450	97	10	87	93	0	93	90	14	76	93	5	88	97	0	97	....do	Do.
No. 4, NW	600	97	11	86	95	1	94	90	14	76	90	6	84	97	1	96	....do	Do.
Blowing Rock:																		
No. 1, base station, elevation 3,130	....	90	7	83	89	1	88	84	12	72	84	2	82	90	1	89	....do	Do.
No. 2, S	450	88	6	82	88	0	88	86	10	76	85	3	82	88	0	88	....do	Do.
No. 3, SE	450	88	2	86	88	1	87	87	7	80	83	−3	86	88	−3	91	....do	Jan. 18, 1916.
No. 4, SE	625	89	6	83	88	0	88	87	9	78	82	−1	83	89	−1	90	....do	Do.
No. 5, SE	800	88	5	83	87	−5	92	85	7	78	81	−2	83	88	−5	93	....do	Dec. 15, 1914.
Bryson:																		
No. 1, base station, elevation 1,800	....	97	19	78	96	2	94	92	11	81	92	2	90	97	2	95	July 18, 1913	Do.
No. 2, N	385	97	21	76	96	2	94	92	12	80	92	5	87	97	2	95	....do	Do.
No. 2a, S	385	97	20	77	96	2	94	93	13	80	92	4	88	97	2	95	....do	Do.
No. 3, summit	570	95	22	73	96	1	95	92	14	78	95	5	90	96	1	95	June 11, 1914	Do.
Cane River:																		
No. 1, base station, elevation 2,650	....	93	10	83	92	3	89	88	11	77	88	−5	93	93	−5	98	July 18, 1913	Dec. 19, 1916.
No. 2, N	190	93	13	80	90	2	88	86	11	75	86	2	84	93	2	91	....do	Dec. 15, 1914.
No. 3, NE	400	93	12	81	90	0	90	85	10	75	86	3	83	93	0	93	July 19, 1913	Do.
No. 4, summit	1,100	94	8	86	93	1	92	90	8	72	87	0	87	94	0	94	....do	Dec. 19, 1914.
Ellijay:																		
No. 1, base station, elevation 2,240	....	95	10	85	94	2	92	92	11	81	90	5	85	95	2	93	July 18, 1913	Dec. 15, 1914.
No. 2, N	310	95	10	85	93	1	92	91	14	77	89	5	84	95	1	94	....do	Do.
No. 3, N	620	92	12	80	90	1	89	89	13	76	87	5	82	92	1	91	July 18, 19, 1913.	Do.
No. 4, N	1,240	90	11	79	90	3	87	89	12	77	84	7	77	90	3	87	....do	Mar. 2, 1914.
No. 5, summit	1,760	......	......	......	88	0	88	90	9	82	86	4	82	90	0	90	July 31, 1915 [1]	Do.
Globe:																		
No. 1, base station, elevation 1,625	....	97	13	84	96	7	89	95	16	79	92	9	83	97	7	90	July 18, 19, 1913.	Dec. 15, 1914.
No. 2, E	300	97	14	83	94	7	87	94	17	77	95	8	87	97	7	90	July 19, 1913	Do.
No. 3, summit	1,000	98	12	86	97	6	91	94	16	78	96	7	89	98	6	92	....do	Do.

[1] No. 5 not established in 1913.

TABLE 3.—*Annual maximum and minimum temperatures and range for the years of observation (on the left) and absolute maximum and minimum for the period (on the right)*—Continued.

[The differences between the averages at the base station and those of the respective slope stations may be seen by simple inspection.]

Principal and slope stations; elevation of base stations above mean sea level (feet).	Height of slope stations above base (feet).	1913			1914			1915			1916			1913–1916.			Dates of absolute maxima.	Dates of absolute minima.
		Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.	Maximum.	Minimum.	Range.		
Gorge:																		
No. 1, base station, elevation 1,400		101	13	88	98	5	93	98	16	82	97	7	90	101	5	96	July 19, 1913	Dec. 15, 1914.
No. 2, NE	290	99	11	88	97	4	93	97	15	82	92	9	83	99	4	95	do	Do.
No. 3, S	615	96	10	86	93	6	87	93	14	79	93	5	88	96	5	91	do	Dec. 19, 1916.
No. {N (old) / NE. (new)}	840	98	11	87	94	7	87	95	16	79	91	9	82	98	7	91	do	Dec. 15, 1914.
No. 5, summit	1,040	100	12	88	95	9	86	95	15	80	91	12	79	100	9	91	do	Do.
Hendersonville:																		
No. 1, base station, elevation 2,200		97	11	86	93	1	92	92	12	80	90	4	86	97	1	96	do	Dec. 16, 1914.
No. 2, E	450	95	14	81	90	4	86	90	13	77	88	6	82	95	4	91	do	Dec. 15, 1914.
No. 3, E	600	94	13	81	91	1	90	90	13	77	89	2	87	94	1	93	do	Do.
No. 4, summit	750	94	14	80	90	1	89	89	14	75	87	4	83	94	1	93	do	Do.
Highlands:																		
No. 1, base station, elevation 3,350		90	12	78	89	2	87	87	11	76	87	8	79	90	2	88	do	Mar. 2, 1914.
No. 2, SE	200	90	12	78	90	2	88	87	11	76	87	5	82	90	2	88	do	Do.
No. 3, SE	325	88	6	82	85	−7	92	82	3	79	85	0	85	88	−7	95	July 18, 1913	Dec. 15, 1914.
No. 4, SE	525	87	9	78	88	−2	90	86	5	81	85	3	82	88	−2	90	June 12, 1914.	Mar. 2, 1914.
No. 5, SE	725	89	9	80	88	−2	90	87	5	82	85	3	82	89	−2	91	July 19, 1913.	Do.
Mount Airy:																		
No. 1, base station, elevation 1,340		95	9	86	99	9	90	100	16	84	91	7	84	100	7	93	July 31, 1915	Jan. 18, 1916.
No. 2, W	160	96	9	87	99	8	91	99	16	83	91	10	81	99	8	91	do	Dec. 27, 1914.
No. 3, E	160	95	10	85	98	8	90	99	17	82	92	8	84	99	8	91	do	Dec. 15, 1914; Jan. 18, 1916
No. 4, summit	360	95	12	83	98	7	91	99	16	83	92	11	81	99	7	92	do	Dec. 27, 1914.
Transon:																		
No. 1, base station, elevation 2,970		91	4	87	92	−4	96	90	9	81	86	3	83	92	−4	96	June 26, 1914	Dec. 15 and 27, 1914.
No. 2, W	150	91	5	86	90	1	89	88	14	74	83	2	81	90	1	89	do	Dec. 16, 1914.
No. 3, W	300	91	5	86	91	1	90	89	11	78	84	3	81	91	1	90	do	Dec. 15, 1914.
No. 4, summit	450	88	4	84	90	0	90	86	11	75	83	3	80	90	0	90	do	Do.
Tryon:																		
No. 1, base station, elevation 950		103	15	88	100	13	87	99	16	83	97	7	90	103	7	96	July 19, 1913	Dec. 20, 1916.
No. 2, SE	380	103	19	84	101	12	89	99	21	78	95	12	83	103	12	91	do	Dec. 15, 1914.
No. 3, SE	570	102	18	84	99	10	89	98	19	79	93	10	83	102	10	92	do	Do.
No. 4, SE	1,100	101	16	85	98	7	91	96	17	79	91	8	83	101	7	94	do	Do.
Wilkesboro:																		
No. 1, base station, elevation 1,240		101	14	87	99	6	93	99	15	84	93	5	88	101	5	96	do	Dec. 20, 1916.
No. 2, N	150	102	14	88	100	8	92	98	15	83	93	8	85	102	8	94	do	Dec. 16, 1914; Jan. 18 and Dec. 20, 1916.
No. 3, N	350	100	14	86	99	10	89	95	17	78	91	12	79	100	10	90	do	Dec. 15, 1914.
No. 4, W	430	100	13	87	98	8	90	96	16	80	91	11	80	100	8	92	do	Do.

RANGE IN TEMPERATURE.

The range in temperature is perhaps not of much importance in the growing of fruit. The principal factor is the minimum, and yet the maximum is also a factor, although much less important. The range simply shows the variation between the two, whether for the year, the month, or the day.

Of course, the range averages the least where the minimum is highest and the maximum lowest, and the range averages the greatest where the minimum is lowest and the maximum highest, or relatively so. We know from the discussion of previous tables that, with only a few exceptions, the maximum is highest and the minimum lowest at the base stations, and the greatest ranges are usually found there. However, as the maximum is the least sometimes on the summit and at other times at a station on the slope lower down and on knobs of slight elevation, and the minimum highest in the center of the thermal belt, located either on the slope or at the summit, there is necessarily a great variation in the position of the least range.

Absolute range.—The absolute ranges for the four-year period for all the stations are included in Table 3, along with the absolute maxima and minima.

The greatest absolute range is 104°, recorded at the base station, Blantyre No. 1, elevation 2,090 feet, this range being the difference between a maximum of 98° and a minimum of −6°. Reference has already been made to the fact that the minima at the Blantyre base station are abnormally low, considering the moderate elevation of the station above sea-level, and it is on this account that the range is so large, the absolute maximum of 98° not being unusual. The least absolute range is 87° at Ellijay No. 4, 3,480 feet above sea level, doubtless because the minimum at that point on the slope is relatively high during nights of inversion, as it is well within the thermal belt, and because the maximum there does not rise to a high point on account of the elevation and the northerly inclination of the slope.

In cities near sea level in the northern States of this country having summer minimum temperatures similar to those at Highlands and Blowing Rock in the North Carolina Mountain Region, winter minima of 25° to 30° below zero and even lower occur. At the Weather Bureau station at Albany, N. Y., for instance, which has the same annual mean temperature as Blowing Rock No. 3, the extremes are much greater, the winters being colder and the summers warmer.

Although the mean temperature at both stations for the four-year period is approximately 49°, the absolute range during this time at Albany is 117°, while at Blowing Rock No. 3 it is only 91°. Taken as a whole, the figures in Table 3 show that the winters are much warmer and the summers much cooler in this mountain region than the winters and summers of northern cities near sea level having the same annual mean temperature.

Figure 50 shows graphically the absolute and annual ranges for the six long slopes, Altapass, Cane River, Ellijay, Globe, Gorge, and Tryon, in addition to the absolute extremes of temperature and the average annual temperature during the four-year research. Data for Blowing Rock and Highlands, at which exceedingly low temperatures occur, are not included, as the stations at both these places are in two groups located on different slopes nor is any other short slope included.

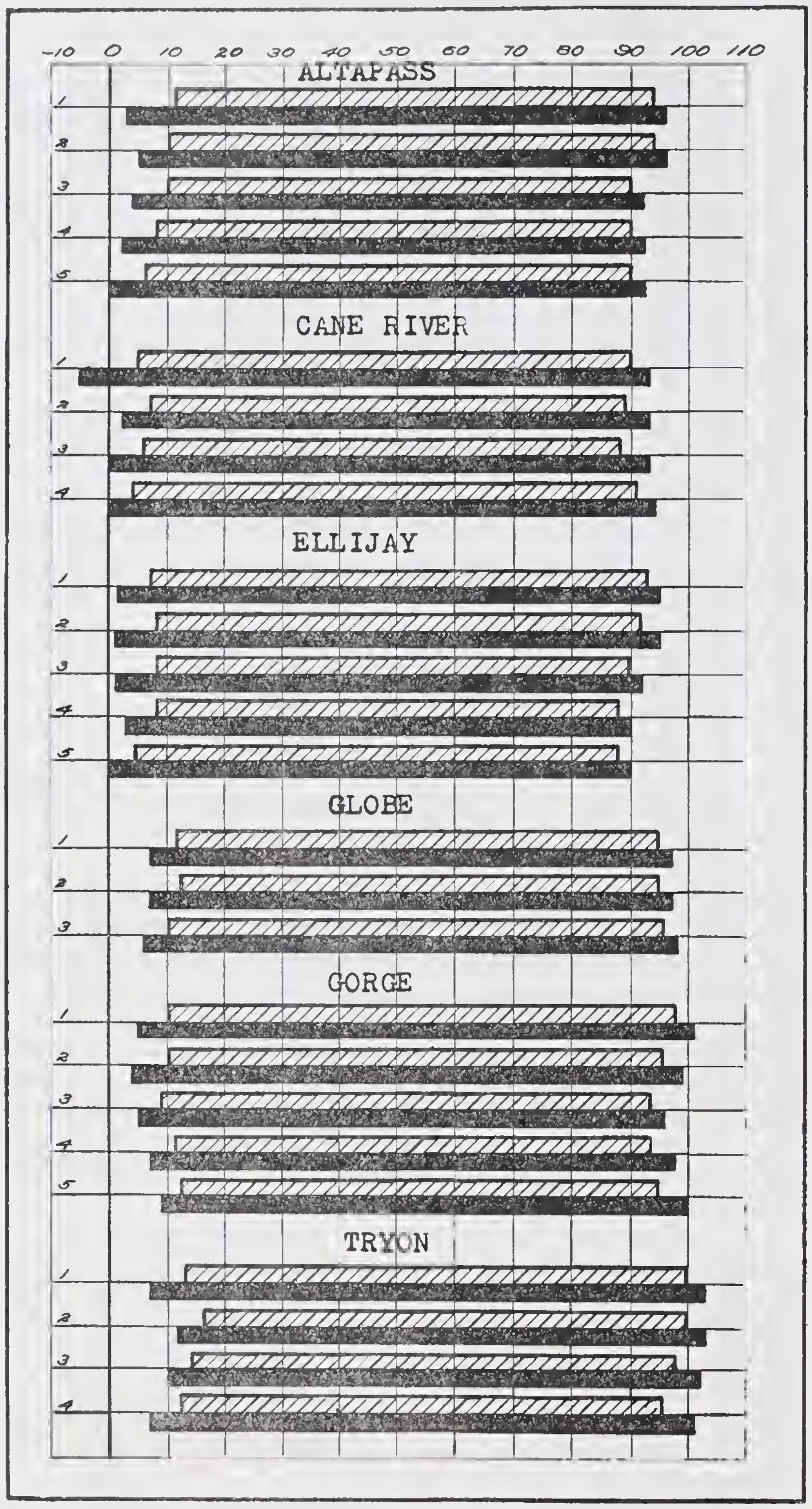

FIG. 50.—Absolute and average annual maximum and minimum temperatures and range, six long slopes. Solid lines show extremes; shaded, averages.

There is a certain uniformity apparent in the variation of the range on these long slopes. The largest absolute ranges are found at the base stations at Altapass, Cane River, Gorge, and Tryon, while the least in every case is at some point on the slope in the thermal belt. The largest range at Globe is on the summit, because of the high maxima registered there, while the largest at Ellijay is at station No. 2, which has the lowest minima on this slope above the base.

Average annual range in temperature.—The variation in average annual range in temperature on the six long slopes, as illustrated in Figure 51, conforms roughly to the variation in absolute range.

The greatest and least absolute ranges and the greatest and least average annual ranges do not, of course, necessarily coincide, because the former are often due to unusual and even abnormal conditions, while the latter are the result of all conditions, both normal and abnormal.

Daily range—Seasonal variation.—For lack of space the table compiled to show the average daily range of temperature on all slopes is omitted in this publication, but, nevertheless, the material may be discussed briefly.

The greatest daily ranges usually occur at the base stations in months most favorable for inversions—May and November—when the maxima are relatively high and the minima low under the influence of clear weather, especially on the valley floors. The least average daily ranges are found in the thermal belt, either on the slopes or at the summits and usually in January and December, months with considerable cloudiness and storm activity, unfavorable for frequent inversions, although with large ranges on individual clear days. While the small range in the thermal belts is, as a rule, due to the high minima found there on nights of inversion, sometimes because of special local conditions, such as those at the No. 3 stations at Asheville and Cane River, a low maximum is equally important. At Altapass and Tryon the middle of the thermal belt is usually located between Nos. 2 and 3, and at No. 3 in both places are found the least average daily ranges, 17.9° and 18.0°, respectively. At Ellijay the smallest average daily range, 17.0°, occurs at No. 4, and this is not only because of the relatively high minima recorded there during inversion conditions, but also because of comparatively low maxima during a portion of the year, as explained under the discussion of "Average maximum temperature." The center of the thermal belt at Cane River lies between Nos. 3 and 4, and at the former station is found the smallest average daily range on that slope, 19.2°, but this is the result of a combination of relatively high minima due to frequent inversions and relatively low maxima due to local exposure, as already explained. It can be seen, then, that the least average daily range is generally coincident with the highest average minima, which, in turn, are found at points locating the middle of the thermal belt during inversion conditions, although unusually low maxima are sometimes factors.

While the base station at Blantyre registered the greatest absolute range in the four-year period, the group at Bryson, as a whole, has the greatest average daily range, probably on account of both the unusually low minima in this broad frost pocket and the high maxima due to the moderate elevation of the group. The greatest annual average daily range at any one station at Bryson, 27.1°, occurs at the base, this being greater than at any other station in the research. Furthermore, the annual average daily range at Bryson, station for station, is greater than on any other slope, and this also can be said for the monthly average daily range, as a rule. The four-year annual daily ranges at the base stations at Blantyre, Ellijay, and Gorge are relatively large, being, respectively, 26.2°, 26.6°, and 25.6°. It will be noted that in each of these instances, including Bryson, the base stations are located on true valley floors, where the exposure insures high maxima on days with clear weather and low minima during nights of inversion and where the elevation above sea level is not necessarily low. Moreover, the vegeta-

tion in any group is usually densest at the base, trapping the heated air during days of sunshine and insuring great loss of heat through radiation at night.

The least average daily range in a group as a whole occurs at Blowing Rock, and the ranges at Highlands, with the exception of No. 3, are nearly as small. Of the five stations at Blowing Rock the lowest average occurs at No. 2, 16.8°. At Highlands the least average daily range occurs at Nos. 1 and 2, the figures being 17.6° for each station. In general, the smallest ranges occur practically always in the most elevated groups, because, in addition to Blowing Rock and Highlands, the higher stations at Transon, Ellijay, Cane River, and Altapass have comparatively small daily ranges.

However, the smallest average daily range, 16.4°, of all the stations in the region is noted at Asheville No. 3, shut in by timber on a northerly slope, 2,825 feet above sea level, but this range, which is 1.4° lower than the variation in the range between the base and the summit and can be used to better advantage in comparisons. This graph will serve to supplement the previous discussion. In every case the largest average range, both seasonal and annual, is seen to be at the base stations, while the position of the least range on the slope varies, always being, however, approximately near the center of the thermal belt.

The largest average daily range for these six slopes in any month, as shown by the graph, is 30.3°, in April at Gorge station No. 1, while the smallest average in any month is 13.3° in January at Ellijay Station No. 4, located 1,240 feet above the valley floor. Moreover, the smallest average daily range for the four years, 17°, is at the same station at Ellijay, while the largest average for the entire period, 26.6°, is also at Ellijay, but at the base station, the latter, in fact, registering a considerable range in all months of the year. This comparison, of

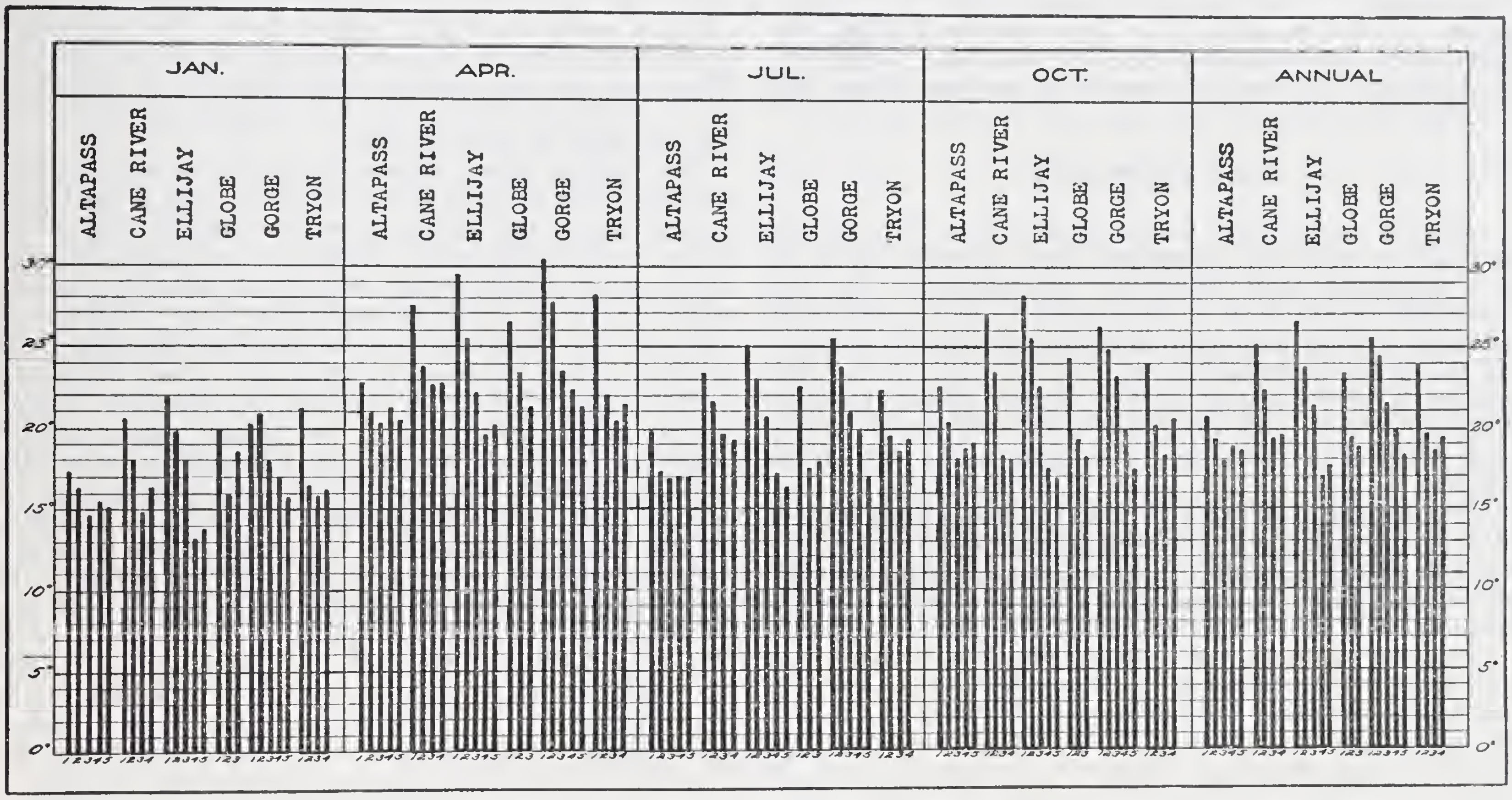

FIG. 51.—Average daily range in temperature, six long slopes. The numbers at the bottom represent the several slope stations.

range for the same length of time at the highest elevation in the research, Highlands No. 5, is due largely to the remarkably low maxima, as already stated, but its high minima are also a factor, as the station is located well within the thermal belt during nights of inversion.

In general, then, the statement of Hann [4] in his Handbook of Climatology that "the amount of range in temperature generally decreases with increasing elevation" holds good for this region, because these observations would definitely show this to be the case were the environments of the stations comparable, aside from elevation.

Figure 51 shows the average daily variation in range, seasonal and annual, on the six long slopes, Altapass, Cane River, Ellijay, Globe, Gorge, and Tryon. For convenience the months of January, April, July, and October are chosen as representative of the various seasons. Long slopes show marked uniformity in the course, has reference to the six long slopes only, because it has already been shown that, for the entire region, the greatest average daily range for the 4-year period is 27.1°, at Bryson station No. 1, and the smallest, 16.4°, at Asheville No. 3.

The average daily range in temperature, whether for the months or for the year, does not indicate much as to the largest ranges that may be observed in a single day, as individually daily ranges are much greater. In the four-year period of the research for the entire region, embracing all stations, the largest range in one day was 52°, observed at Blantyre station No. 1 on November 13, 1913. Other relatively large ranges were 51° at Bryson No. 1 on April 19, 1916; 48° at Gorge No. 1 May 1, 1916; and 47° at Elijay No. 1 May 21, 1914 all four during clear weather favorable for large inversions. On the other hand, the smallest daily ranges observed were 1° at Ellijay No. 4 January 3, 1914, and 2° at Asheville No. 3 January 2, 1914, both during cloudy weather.

[4] Hann, Dr. Julius, "Handbook of Climatology," pp. 273-274. English translation by Ward.

The range in temperature, of course, depends largely upon the weather conditions, there being much greater range during periods of sunshine than in cloudy weather. In clear weather the maximum temperature rises to a high point and the minimum falls correspondingly low, thus permitting a considerable range; but during cloudy weather, when the sunshine is shut off, the maximum during the daytime is rather low, and at night the minimum is high, as the loss of heat by radiation with the sky obscured is comparatively small.

So in Figure 51 we have seen that the largest daily ranges occur in the spring and autumn at the time of largest inversions, when the weather conditions are most settled. The greatest average daily ranges are shown to be in the months of April and October, while the least are recorded in January, usually stormy and cloudy, and in July, with a high percentage of cloudiness and with small inversions, April having the largest ranges and January the smallest. Doubtless, the range is low in January because of the comparatively high minima and in July because of the comparatively low maxima. Moreover, in April and October, the months of greatest range, the maxima are comparatively high and the minima low.

MEAN TEMPERATURE.

Monthly and annual mean temperatures.—The figures in Table 4 have been computed from the true means of the maximum and minimum temperatures. In the mountain region there is no uniformity in the variation of mean temperature with elevation, and this is because of the great irregularities in both the maximum and minimum temperatures on the various slopes, particularly the latter. On this account it hardly seems advisable to discuss the mean temperatures at any great length.

It is apparent at a glance that the mean temperature does not decrease with elevation at any uniform rate and that in some instances there is even an increase with elevation, largely because of the frequent periods of inversion, at which times the base station is the coldest.

It seems necessary to touch only briefly upon the variation in the readings on the individual slopes. A cursory inspection of the differences between the means of base stations and those of the respective slopes indicates that sometimes the lowest mean is at the base station, at other times at the summit, and at still other times at some point midway between. Where there are base stations located in distinct frost pockets, as at stations No. 3 at both Blowing Rock and Highlands and stations No. 1 at both Blantyre and Bryson, the lowest means will be found there, and, as previously shown, these stations have also the lowest four-year average minima. On such slopes as Mount Airy and Wilkesboro the mean averages the lowest at the base, and on the long slopes, as at Altapass, Ellijay, and Tryon, the mean annual temperature is generally lowest at the summit. But where there are coves or frost pockets on long slopes, as at station No. 3 at Cane River and Nos. 2 and 3 at Gorge, the lowest means will be at those points, instead of at the summits. Generally, the variation in mean temperature on a slope depends more upon the variation in minimum temperature than upon the maximum, but station No. 3 at Asheville, a slope station, owes its low mean solely to the low maximum, where the shelter is on a northerly slope with timber above, which, as stated previously, shuts off the sunshine practically all the time. Moreover, the low mean at Cane River No. 3, referred to above, is largely due to the low maxima at times when the sunshine is shut off early.

The highest mean temperatures are found invariably at some point above the base and in no case is the highest annual mean, and seldom even the mean in any month, found on the valley floor. Whether the highest is found on the slope or at the summit, the place is usually coincident with the center of the thermal belt during nights of inversion, this being the level of the least average range, as well. Thus on most of the slopes where the thermal belts are centered at the summit, as Blantyre, Bryson, Gorge, and Hendersonville, the highest mean temperatures are found at those levels, although in some other cases, as Cane River, Mount Airy, and Wilkesboro, the highest mean temperatures are lower down on the slope, in the latter instances the influence of the maximum temperature counteracting that of the minimum. The minimum, however, as stated before, stands out most prominently as the factor affecting the position of the mean temperature, as shown not only by the number of places having the highest mean at the summit, but also by certain other places where the highest mean is lower down on the slope, as at Altapass and Tryon near Stations No. 2 in the center of the thermal belt.

TABLE 4.—*Monthly and annual mean temperatures, 1913–1916.*

Principal and slope stations, elevation base station above mean sea level (feet).	Height of slope stations above base (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	4-year annual.
Altapass:														
No. 1, base station, elevation 2,230		[1] 39.6	[1] 38.4	[2] 41.4	[1] 55.1	64.2	69.0	72.3	71.3	64.6	57.4	47.9	38.5	[1] 54.9
No. 2, SE	250	[1] 39.4	[1] 38.3	[2] 40.9	[1] 55.3	64.6	69.4	72.2	71.2	65.2	58.2	48.2	38.4	[1] 55.1
No. 3, SE	500	[1] 38.5	[1] 37.4	[2] 39.8	[1] 53.9	63.6	68.2	71.0	70.2	64.1	56.8	47.1	37.2	[1] 53.9
No. 4, SE	750	[1] 36.9	[1] 35.7	[2] 40.4	[1] 52.4	62.0	66.6	69.4	68.9	62.4	55.7	45.9	35.6	[1] 52.7
No. 5, summit	1,000	36.4	35.2	38.0	52.0	61.0	65.8	69.1	68.2	62.0	54.6	45.2	35.3	[1] 51.8
Asheville:														
No. 1, base station, elevation 2,445		41.7	38.9	42.7	53.7	63.2	68.2	71.2	70.7	64.6	56.8	47.2	38.5	54.8
No. 2, N	155	41.4	38.4	42.4	54.2	64.2	68.6	71.1	70.3	64.9	56.3	47.1	38.0	54.8
No. 2a, S	155	42.4	39.3	43.1	55.0	64.2	68.9	71.5	71.0	65.6	57.6	48.3	39.4	55.5
No. 3, N	380	40.7	37.8	41.8	54.0	64.2	68.1	70.6	69.5	63.2	55.6	46.8	37.5	54.2
No. 3a, S	380	42.4	39.8	43.6	55.9	65.6	69.8	72.3	71.5	65.7	58.2	50.0	39.6	56.2
Blantyre:														
No. 1, base station, elevation 2,090		41.4	39.1	43.4	53.6	63.1	69.2	72.2	71.5	64.6	56.1	45.2	37.3	54.7
No. 2, NW	300	41.1	38.7	43.6	54.9	63.9	68.8	71.4	70.6	63.9	55.6	45.8	37.4	54.9
No. 3, NW	450	41.6	39.4	43.7	55.6	65.0	69.1	71.8	70.9	64.2	57.0	47.9	38.2	55.4
No. 4, NW	600	42.4	40.7	44.6	57.1	66.1	70.1	72.9	72.0	66.0	58.4	49.4	39.2	56.6

[1] 3-year average.

[2] 2-year average.

TABLE 4.—*Monthly and annual mean temperatures, 1913–1916*—Continued.

Principal and slope stations, elevation base station above mean sea level (feet).	Height of slope stations above base (feet).	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	4-year annual.
Blowing Rock:														
No. 1, base station, elevation 3,130	....	37.1	35.0	38.5	50.6	60.3	65.9	68.8	68.0	61.8	54.0	44.2	34.8	51.6
No. 2, S	450	36.9	34.6	38.1	50.8	60.9	66.0	68.6	67.6	61.6	53.9	45.0	35.1	51.6
No. 3, SE base sta	450	35.0	32.6	36.4	47.9	57.4	63.4	66.0	65.2	58.3	51.8	40.9	32.7	49.0
No. 4, SE	625	36.1	33.7	37.1	49.3	59.5	64.8	68.0	66.9	60.6	53.4	43.8	34.2	50.6
No. 5, SE	800	35.4	32.8	36.6	48.7	58.9	64.4	67.3	66.4	60.0	52.4	42.8	33.2	50.0
Bryson:														
No. 1, base station, elevation 1,800	....	[2] 42.0	[1] 39.3	[1] 41.7	54.6	64.0	69.7	72.8	72.3	66.3	57.4	[1] 46.2	[1] 37.6	55.3
No. 2, N	385	[2] 41.9	[1] 39.9	[1] 42.2	55.3	64.7	69.4	72.3	71.8	66.1	57.7	[1] 46.9	[1] 37.1	55.4
No. 2a, S	385	[2] 43.0	[1] 40.7	[1] 42.9	56.3	65.2	69.9	72.6	72.2	66.2	57.8	[1] 47.8	[1] 38.3	56.1
No. 3, summit	570	[2] 42.6	[1] 41.0	[1] 43.7	58.7	67.2	70.9	73.3	72.3	66.3	57.9	[1] 48.2	[1] 37.6	56.6
Cane River:														
No. 1, base station, elevation 2,650	....	[1] 38.5	[1] 36.2	[1] 38.3	51.0	60.8	66.4	69.8	69.4	62.5	53.9	43.3	35.4	52.1
No. 2, N	190	[1] 38.7	[1] 36.5	[1] 39.0	52.4	62.1	67.0	69.9	69.2	62.6	54.7	45.4	36.4	52.9
No. 3, NE	400	[1] 36.5	[1] 35.0	[1] 37.7	52.3	62.4	66.9	69.6	68.5	61.6	53.3	43.9	34.5	51.8
No. 4, summit	1,100	[1] 36.7	[1] 35.0	[2] 36.2	52.0	63.0	67.0	69.6	68.4	62.0	54.2	45.6	35.0	52.0
Ellijay:														
No. 1, base station, elevation 2,240	....	[1] 41.0	[1] 39.4	[1] 41.5	54.2	63.2	68.3	71.4	70.8	64.8	56.4	46.3	38.6	54.7
No. 2, N	310	[1] 41.0	[1] 39.3	[1] 42.0	55.4	64.2	68.7	71.4	70.4	64.7	56.4	47.1	38.8	55.0
No. 3, N	620	[1] 40.8	[1] 39.1	[1] 41.3	54.8	64.1	68.2	70.7	69.8	64.1	56.4	47.9	38.9	54.7
No. 4, N	1,240	[1] 39.3	[1] 37.8	[1] 40.0	54.6	64.3	68.2	70.6	69.6	64.0	56.3	47.5	37.8	54.2
No. 5, summit	1,760	[2] 39.5	[2] 37.6	[1] 38.7	[1] 53.7	[1] 63.5	[1] 66.8	[1] 68.8	[1] 68.5	63.4	[1] 56.3	[1] 46.6	[1] 36.1	53.3
Globe:														
No. 1, base station, elevation 1,625	....	41.0	39.5	43.8	55.0	64.8	70.1	73.2	72.2	65.9	58.4	47.6	38.7	55.8
No. 2, E	300	40.7	39.8	44.2	56.5	66.4	70.4	73.2	72.1	66.2	58.7	48.4	38.4	56.2
No. 3, summit	1,000	41.0	39.2	43.5	56.7	66.8	70.6	73.3	71.9	65.6	58.5	49.0	38.3	56.2
Gorge:														
No. 1, base station, elevation 1,400	....	40.5	39.6	44.7	55.5	65.2	70.5	73.8	72.7	66.0	58.2	46.9	37.7	55.9
No. 2, NE	290	40.4	39.1	43.8	54.9	64.7	69.7	72.9	72.2	65.2	57.5	47.0	37.9	55.5
No. 3, S	615	40.8	39.4	43.8	55.5	64.7	69.0	72.2	71.1	64.7	57.2	48.0	38.2	55.4
No. 4, N. (old), NE. (new)	840	40.7	39.3	43.8	56.6	66.4	70.3	73.0	72.0	65.4	57.9	48.6	38.1	56.0
No. 5, summit	1,040	40.8	39.6	43.7	57.3	67.0	70.8	73.5	72.0	65.6	58.3	48.6	38.7	56.3
Hendersonville:														
No. 1, base station, elevation 2,200	....	[1] 39.1	[1] 38.5	[1] 41.4	53.3	62.5	68.2	71.3	70.6	63.4	55.6	45.3	37.4	53.9
No. 2, E	450	[1] 39.5	[1] 37.8	[1] 40.9	53.4	63.0	68.2	70.9	69.9	63.4	55.6	46.1	37.5	53.8
No. 3, E	600	[1] 39.5	[1] 38.1	[1] 40.7	54.1	63.7	68.3	71.0	69.9	63.6	56.0	46.3	36.8	54.1
No. 4, summit	750	[1] 39.5	[1] 37.9	[1] 40.5	54.1	64.0	68.3	71.2	70.1	64.2	56.6	47.8	37.6	54.3
Highlands:														
No. 1, base station, elevation 3,350	....	[1] 39.5	[1] 36.2	[1] 43.3	53.7	62.9	67.1	69.6	69.0	63.5	55.8	47.5	38.6	53.6
No. 2, SE	200	[1] 40.7	[1] 39.3	[1] 40.4	53.6	63.3	67.4	69.6	69.2	63.6	56.1	47.8	39.6	54.1
No. 3, SE base sta	325	[2] 37.5	[1] 33.0	[1] 35.8	47.9	57.1	61.6	64.5	64.0	57.5	50.2	41.3	34.0	48.7
No. 4, SE	525	[1] 36.5	[1] 33.8	[1] 35.5	50.8	60.6	64.8	67.2	66.1	60.0	53.0	45.1	35.3	50.6
No. 5, SE	725	[1] 36.0	[1] 33.6	[1] 34.9	51.0	61.2	65.4	68.2	67.0	60.9	53.4	45.9	36.2	51.1
Mount Airy:														
No. 1, base station, elevation 1,340	....	41.4	39.3	44.7	56.9	66.2	72.0	74.9	73.3	66.9	58.9	48.2	38.7	56.8
No. 2, W	160	41.4	[1] 39.3	45.0	57.6	67.8	73.2	75.7	73.7	67.9	60.2	49.8	39.2	57.4
No. 3, E	160	41.5	39.4	44.9	57.0	66.7	72.2	74.8	73.4	67.3	59.1	48.9	39.3	57.0
No. 4, summit	360	41.0	39.1	44.4	57.3	67.2	72.4	75.0	73.4	67.4	59.7	49.4	38.6	57.1
Transon:														
No. 1, base station, elevation 2,970	....	37.5	34.6	38.8	50.5	59.4	65.3	68.7	67.4	60.8	53.5	42.7	34.2	51.2
No. 2, W	150	37.4	34.6	38.6	51.2	60.8	66.0	68.5	67.6	60.6	52.9	44.0	34.1	51.4
No. 3, W	300	37.1	34.7	38.5	51.6	61.0	66.5	69.1	67.8	61.8	54.1	44.6	34.1	51.8
No. 4, summit	450	[1] 35.6	[1] 34.2	[1] 36.1	50.5	60.6	65.8	68.4	67.6	61.6	53.7	44.3	33.9	51.0
Tryon:														
No. 1, base station, elevation 950	....	44.9	43.8	48.3	58.7	68.5	74.8	77.7	76.6	69.8	62.4	50.8	42.8	60.0
No. 2, SE	380	46.0	45.1	49.7	61.6	70.6	75.4	78.6	76.9	71.1	63.6	54.4	44.0	61.4
No. 3, SE	570	45.1	43.8	47.9	59.8	69.0	73.8	76.5	75.2	69.1	61.3	52.4	42.1	59.6
No. 4, SE	1,100	43.4	42.0	46.2	58.0	67.2	71.8	74.6	73.5	67.5	60.4	51.0	40.8	58.0
Wilkesboro:														
No. 1, base station, elevation 1,240	....	41.6	40.0	45.5	57.0	66.1	72.4	75.5	73.8	67.0	59.2	48.3	39.0	57.1
No. 2, N	150	42.2	40.4	45.8	58.1	67.6	72.7	75.8	74.2	67.1	59.4	49.2	38.9	57.6
No. 3, N	350	42.8	40.9	46.1	58.2	68.0	72.7	75.7	74.0	67.4	59.9	50.4	40.0	58.0
No. 4, W	430	42.4	40.2	45.5	58.2	67.5	72.6	75.6	74.2	67.2	59.4	50.5	39.6	57.8

[1] 3-year average. [2] 2-year average.

Rate of decrease in monthly and annual mean temperature on six selected long slopes.—In Table 4a are brought together the six places having stations on slopes with a difference in elevation of 1,000 feet or more between the lowest and highest, the monthly and annual values being given for these stations, together with the rate of decrease in mean temperature with elevation.

Altapass, with a rate of decrease of 1° for 323 feet of elevation, is the only one that shows a decrease approaching the usual rate in free air. The stations at Altapass are, of course, on a regular slope with station No. 1 several hundred feet above the valley floor. On this account, during nights of inversion the summit station is seldom warmer than No. 1, the thermal belt usually not reaching the more elevated sections, as on most of the other slopes. On some of these long slopes the night inversions are sufficiently pronounced to make the average monthly and annual values at the summit higher than at the base.

Thus Cane River shows a decrease in mean temperature at the rate of only 1° for each 11,000[2] feet, Ellijay for each 1,257 feet, Tryon for each 550 feet; while at Globe and Gorge, the mean temperature is actually greatest at the summit.

TABLE 4a.—*Monthly and annual mean temperatures on the six long slopes, showing rate of increase or decrease with elevation, 1913–1916.*

[The slopes selected for this comparison have a difference in elevation of 1, 000 feet or more between the base and summit station. The difference in temperature between the base and summit stations on each slope is given, as well as the difference in feet for each degree difference in temperature.]

Slopes and stations.	Elevation.[1]		January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.	Annual
	Base.	Summit.													
	Feet.	*Feet.*													
Altapass No. 1	2,230	....	39.6	38.4	41.4	55.1	64.2	69.0	72.3	71.3	64.6	57.4	47.9	38.5	54.9
Altapass No. 5	....	1,000	36.4	35.2	38.0	52.0	61.0	65.8	69.1	68.2	62.0	54.6	45.2	35.3	51.8
Difference	....	....	−3.2	−3.2	−3.4	−3.1	−3.2	−3.2	−3.2	−3.1	−2.6	−2.8	−2.7	−3.2	−3.1
Feet for 1° difference.[2]	....	....	312	312	294	323	312	312	312	323	385	357	370	312	323
Cane River No. 1	2,650	....	38.5	36.2	38.3	51.0	60.8	66.4	69.8	69.4	62.5	53.9	43.3	35.4	52.1
Cane River No. 4	....	1,100	36.7	35.0	36.2	52.0	63.0	67.0	69.6	68.4	62.0	54.2	45.6	35.0	52.0
Difference	....	....	−1.8	−1.2	−2.1	+1.0	+2.2	+0.6	−0.2	−1.0	−0.5	+0.3	+2.3	−0.4	−0.1
Feet for 1° difference.[2]	....	....	611	917	524	1,100	500	1,833	5,500	1,100	2,200	3,667	478	2,750	[2] 11,000
Ellijay No. 1	2,240	....	41.0	39.4	41.5	54.2	63.2	68.3	71.4	70.8	64.8	56.4	46.3	38.6	54.7
Ellijay No. 5	....	1,760	39.5	37.6	38.7	53.7	63.5	66.8	68.8	68.4	63.3	56.3	46.6	36.1	53.3
Difference	....	....	−1.5	−1.8	−2.8	−0.5	+0.3	−1.5	−2.6	−2.3	−1.4	−0.1	+0.3	−2.5	−1.4
Feet for 1° difference.[2]	....	....	1,173	978	629	3,520	5,867	1,173	677	765	1,257	17,600	5,867	704	1,257
Globe No. 1	1,625	....	41.0	39.5	43.8	55.0	64.8	70.1	73.2	72.2	65.9	58.4	47.6	38.7	55.8
Globe No. 3	....	1,000	41.0	39.2	43.5	56.7	66.8	70.6	73.3	71.9	65.6	58.5	49.0	38.3	56.2
Difference	....	....	0.0	−0.3	−0.3	+1.7	+2.0	+0.5	+0.1	−0.3	−0.3	+0.1	+1.4	−0.4	+0.4
Feet for 1° difference.[2]	....	....	....	3,333	3,333	588	500	2,000	10,000	3,333	3,333	10,000	714	2,500	2,500
Gorge No. 1	1,400	....	40.5	39.6	44.7	55.5	65.2	70.5	73.8	72.7	66.0	58.2	46.9	37.7	55.9
Gorge No. 5	....	1,040	40.8	39.6	43.7	57.3	67.0	70.8	73.5	72.0	65.6	58.3	48.6	38.7	56.3
Difference	....	....	+0.3	0.0	−1.0	+1.8	+1.8	+0.3	−0.3	−0.7	−0.4	+0.1	+1.7	+1.0	+0.4
Feet for 1° difference.[2]	....	....	3,467	....	1,040	578	578	3,467	3,467	1,486	2,600	10,400	612	1,040	2,600
Tryon No. 1	950	....	44.9	43.8	48.3	58.7	68.5	74.8	77.7	76.6	69.8	62.4	50.8	42.8	60.0
Tryon No. 4	....	1,100	43.4	42.0	46.2	58.0	67.2	71.8	74.6	73.5	67.5	60.4	51.0	40.8	58.0
Difference	....	....	−1.5	−1.8	−2.1	−0.7	−1.3	−3.0	−3.1	−3.1	−2.3	−2.0	+0.2	−2.0	−2.0
Feet for 1° difference [2]	....	....	733	611	524	1,571	846	367	355	355	478	550	5,500	550	550

[1] Base station above sea-level; summit above base.
[2] The datum "Feet for 1 degree difference" obviously fails of any physical significance when the temperature differences between slope stations are quite small.—*Ed.*

Monthly and annual mean temperature at the two stations having respectively the highest and lowest elevations.—In a comparison between the station having the lowest altitude above sea level, the base station No. 1 in the valley floor at Tryon, with an elevation of 950 feet and a mean temperature of 60°, and the most elevated station, Highlands No. 5, with an elevation of 4,075 feet above sea level and a mean of 51.1°, we find for this difference in elevation of 3,125 feet a difference in mean temperature for the entire period of 8.9°, which is equivalent to a decrease of 1° for each 351 feet, as shown in Table 4b.

TABLE 4b.—*Monthly and annual mean temperatures at stations having the highest and lowest elevations, respectively, showing the rate of decrease with elevation, 1913–1916.*

Stations.	Elevation.	January.	February.	March.	April.	May.	June.
	Feet.						
Tryon, No. 1	950	44.9	43.8	48.3	58.7	68.5	74.8
Highlands, No. 5	4,075	36.0	33.6	34.9	51.0	61.2	65.4
Difference	....	−8.9	−10.2	−13.4	−7.7	−7.3	−9.4
Number feet for 1° difference	....	351	306	233	406	428	332

Stations.	Elevation.	July.	August.	September.	October.	November.	December.	Annual.
	Feet.							
Tryon, No. 1	950	77.7	76.6	69.8	62.4	50.8	42.8	60.1
Highlands, No. 5	4,075	68.2	67.0	60.9	53.4	45.9	36.2	51.0
Difference	....	−9.5	−9.6	−8.9	−9.0	−4.9	−6.6	−9.1
Number feet for 1° difference	....	329	326	351	347	638	473	332

INVERSIONS.

Topographical and meteorological factors in inversions.—Inversions, which are primarily radiation phenomena, are, of course, most frequent during clear or partly cloudy nights. A low fog often covers the valleys, in which case the inversions continue till the fog is lifted or dissipated. A calm or no more than a light wind is essential on the valley floor, but a moderate or brisk southerly wind at the higher elevations does not prevent inversions, but may actually increase the degree considerably, as will be shown later, such a wind being characteristic of the Cyclonic or Overflow Type. The largest individual inversions occur when a HIGH centered to the east and southeast of the region is followed by a rapid recovery from low temperature. This is especially characteristic of the Intermediate Type, when a tendency to rising temperature is generally shown at the higher levels at an earlier hour than on the valley floor, or when the temperature on the valley floor is still falling.

The factors which in varying combinations are most effective in causing inversions may be divided into two classes, topographical and meteorological, the former, of course, being absolutely essential as a foundation upon which the meteorological conditions may work.

The topographical features may be stated as follows: Variation in the conditions in the valley floor, whether flat or inclined, broad or narrow, open or inclosed; the direction, steepness, height, and uniformity of slope; the surface area of the slope itself, with special reference to that of the summit, whether a knob, ridge, or plateau; location and character of opposing slopes, if any; general mass of mountains in the immediate vicinity; density or lack of vegetal cover and forest growth; and, finally, the elevation above sea level.

The meteorological factors are the state of weather as to cloudiness and precipitation; the direction and velocity of wind; absolute humidity; relative humidity, especially when the dewpoint is likely to be reached; position of the high and low pressure areas; and the length of the night.

We might go through the entire list of groups of stations used in this research, noting the individual characteristics of the slopes upon which the stations are located and find that no two are alike. These slopes of varying topography furnish many complications in the study, as each factor is important and affects the loss of heat by radiation in a more or less degree. The variation is in itself helpful, as it adds to the scope and value of the research.

A large number of tables and graphs have been prepared in addition to those already discussed with a view of covering the various features of the phenomenon of inversion in a comprehensive manner, and an examination of these now follow.

Selected months of inversions, on the long slope at Ellijay and on the short slope at Highlands.—Table 5, which shows the daily minimum temperatures at Ellijay, the longest slope employed in the research, for May, 1914, together with general weather conditions, illustrates a period with marked inversions occurring almost continually throughout the month, there being only three nights on which inversions did not occur, the 5th, 8th, and 9th. For this month as a whole the minima at stations Nos. 4 and 5, with elevations of 1,240 and 1,760 feet, respectively, above the base, average 8.3° and 8° higher than at the base station. Moreover, on two nights, the 21st and 29th, the minimum at No. 5 was 18° higher than at the base. On the 5th and 9th there are norms to approximately adiabatic conditions, the minima steadily decreasing from the base to the summit, station No. 5 reading on the 5th and 9th 6° and 7°, respectively, below the minima at the base. On the 8th the difference was only 4°, and, while on the 18th the minimum at the summit station was 1° lower than at the base, there was a slight inversion shown at the intermediate stations on the slope. The total monthly precipitation was 0.89 inches, rain being recorded on only six days. The weather was mostly clear throughout the month, with but few instances of cloudiness. The largest inversions occurred with light winds from the northwest to southwest. On the nights when no inversions were noted either the weather was partly cloudy or cloudy or the wind was moderate to brisk.

These large inversions on the long slope at Ellijay during May, 1914, were even exceeded in range on the short slope in the Waldheim orchard at Highlands, 15 miles distant, as shown in Table 6. A comparison is here afforded of the conditions on the longest slope, Ellijay, 1,760 feet, and on one of the shortest slopes, the Waldheim orchard, 400 feet. The average difference for the month in minima between Nos. 3 and 5, the base and summit stations in the Waldheim orchard, is 9.9°, as compared with the difference of 8.3° between Nos. 1 and 4 at Ellijay, the latter, 1,240 feet above the base and 520 feet below the summit, marking the center of the thermal belt. On individual nights the inversions at Highlands exceeded in amount those at Ellijay by as much as 10°, as, for instance, on the night of the 22d, when the minima at Nos. 3 and 5 in the Waldheim orchard were, respectively, 31° and 56°, a difference of 25° in 400 feet, and those at Ellijay Nos. 1 and 4, 41° and 56°, respectively, a difference of 15° in 1, 240 feet. Moreover, inversions of 20° or over, occurred in the Waldheim orchard on four nights, with a maximum difference of 25° on the 22d, as noted above, while at Ellijay there were no inversions over 20°, the greatest being 18°.

The month of May, 1914, from the standpoint of inversions was, of course, most unusual, there being a larger number during that month than in any other month of the entire period of the research, with the single exception of November, 1913, when unfortunately Ellijay station No. 5 was not in operation.

No less remarkable than the comparison of inversions at Ellijay and Highlands for May, 1914 (Tables 5 and 6), is that for these same slopes during November, 1914, included in Tables 7 and 8. While the number of nights with inversions on the Ellijay slope is not so large in the latter month, still the degree of individual inversions is greater, as well as the average degree. There were inversions November 7 and 25 of 23° and 21°, respectively, between the base and summit, the first named exceeding the May record by 5°. The week from the 1st to the 7th of November, 1914, is probably one of the best periods of continous inversion weather of any autumn during the research.

The inversion conditions on the Highlands slope in November, 1914, were even more pronounced than in the previous May at that place as regards both frequency and range, and it is probable that in no other period on any slope employed in this research were they so marked. On only one night was the minimum at No. 5 lower than at the base station, No. 3, and on one night the minima were the same at both stations. On the other 28 nights there were inversions of greater or less degree between the base and the summit. Including all 30 nights, the average at No. 5 exceeded

that at No. 3 by 11°. There were six nights with differences exceeding 20°. An inversion of 25° was registered on this slope on the 7th, the same night an inversion of 23° was observed on the long slope at Ellijay. While these figures for Higlands concern Nos. 3 and 5 only, with a difference in elevation of 400 feet, the inversions on this slope are often seen to be quite pronounced as low as No. 4, which is only 200 feet above the base. The greatest inversion at that point in November, 1914, was 20° on the 3d. However, occasionally when small inversions are noted at No. 5, the minima are seen to be somewhat lower at No. 4 than at No. 3. The large inversions on the short slope at Highlands are mostly due to the unusually low minima registered in the frost pocket at No. 3 and to the fact that No. 5 is located just below a small knob with no opposing slope close by, so that at that level the amount of air free available for interchange is limitless. The degree of inversion at Ellijay is naturally not so great as at Highlands, partly because of the higher readings at the base station of the former.

The large number of inversions during the months of May and November, 1914, is due to the settled weather conditions with clear skies, light wind, little precipitation, and low absolute humidity; and these conditions are in strong contrast to those of the month of July, 1916. At Ellijay (see Table 9) small inversions occurred during that month in the lower levels between Nos. 1 and 2 on 13 nights and between Nos. 1 and 4 and between Nos. 1 and 5 on but 9 and 7 nights, respectively. The weather was unusually cloudy and rainy, with but eight clear days, and a total precipitation of 13.71 inches, an unusual record for a summer month. For the entire month the minimum at the base station, No. 1, averaged the highest of the five stations, 2.9° higher than the summit station, No. 5, while in the month of November, 1914 (see Table 7), No. 1 averaged 8.8° lower than the summit station. Summer inversions are mostly of the Anticyclonic Type and are ordinarily as frequent as those of spring and autumn, but much smaller in range on account of the high humidity and cloudiness. The month of July, 1915, with more settled weather, in contrast to July, 1916, was characterized by frequent inversions, as shown by the conditions prevailing at Ellijay (Table 10). Inversions were noted in that month every night between stations Nos. 1 and 2, on 29 nights between Nos. 1 and 4, and on 28 nights up to the level of No. 5. For the entire month No. 1 averaged the lowest, while the highest average was at No. 4, 4.7° higher than No. 1.

Winter inversions resemble somewhat in range and development those of spring and autumn, but the degree of inversion is more fully under the control of passing weather than at any other time of the year. All three types are found in that season, but the Cyclonic Type is by far the most prevalent. During the colder months well developed periods of inversion are usually of short duration and relatively infrequent, but individual cases offer most interesting studies

Inversions in the winter months are shown fairly well by Tables 11 and 12, for the months of January, 1916, and February, 1915, respectively, at Ellijay. The inversions were larger and more frequent in the selected February than in January, conditions in the former month being more settled and permitting inversions of the Anticyclonic or Ideal Type on several days in succession. On 17 nights in the February month the center of the thermal belt reached on this slope up to station No. 4, the average excess at stations Nos. 5 and 4 over the base station for the month being, respectively, 2.3° and 3.8°. The largest inversion was 16° on the 13th. In January, 1916, the inversions were much less frequent and less pronounced, and were largely of the Recovery and Cyclonic Types. The largest inversions were noted at Nos. 3 and 4, with excesses over No. 1 of 10° and 12°, respectively, the greatest excess at No. 5 over No. 1 being 9° on the 4th. During this month No. 5 averaged 0.4° lower than the base station and on only nine nights did the upper station average higher than the base.

Tables 5 to 12, inclusive, embracing data for the slopes at Ellijay and Highlands, serve to especially illustrate the phenomenon of inversion in the mountain region, and Tables 11 and 12 will be used later in connection with the discussion of norms.

TABLE 5.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, May, 1914 (selected month showing large inversions), Ellijay.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature.					Precipitation at 6 p. m. (inches).	Wind.				State of weather.	
	Station 1, base.	Station 2, N., 310.[1]	Station 3, N., 620.[1]	Station 4, N., 1,240.[1]	Station 5, summit, 1,760.[1]		Sunrise.		Sunset.		Previous night.	Day.
							Dir.	Force.	Dir.	Force.		
1....	40	41	43	46	47	0.00	w.	Mod..	w.	Mod...	Clear....	Clear.
2....	37	39	44	46	45	0.00	w.	...do...	sw.	...do...	...do.....	Do.
3....	41	45	49	50	50	0.00	sw.	...do...	sw.	...do...	...do.....	Do.
4....	54	55	56	55	54	0.11	sw.	...do...	sw.	...do...	Cloudy..	Cloudy.
5....	59	58	57	54	53	0.43	w.	...do...	nw.	...do...	...do.....	Pt. cldy.
6....	48	53	57	56	53	0.00	nw.	...do...	nw.	...do...	Clear....	Clear.
7....	45	47	50	53	53	0.05	w.	...do...	sw.	...do...	...do.....	Pt. cldy
8....	47	47	47	43	43	0.13	w.	Brisk..	nw.	Brisk..	Pt. cldy.	Clear.
9....	45	42	41	39	38	0.00	nw.	...do...	nw.	...do...	...do.....	Do.
10....	35	37	41	44	46	0.00	w.	Mod...	w.	Mod...	...do.....	Do.
11....	44	49	54	59	57	0.00	w.	...do...	w.	...do...	...do.....	Do.
12....	49	54	58	62	59	0.00	w.	...do...	sw.	...do...	...do.....	Do.
13....	54	54	57	59	57	0.00	sw.	...do...	sw.	...do...	...do.....	Do.
14....	45	48	48	47	50	0.00	w.	...do...	w.	Brisk..	...do.....	Do.
15....	39	40	43	44	41	0.00	w.	...do...	w.	Mod...	...do.....	Do.
16....	39	42	46	48	47	0.00	w.	...do...	w.	...do...	...do.....	Do.
17....	42	46	48	52	50	0.00	n.	...do...	ne.	...do...	...do.....	Pt. cldy.
18....	49	51	51	51	48	0.00	ne.	Brisk..	ne.	Brisk..	...do.....	Clear.
19....	34	40	46	45	45	0.00	n.	Mod...	nw.	...do...	...do.....	Do.
20....	35	39	44	50	50	0.00	nw.	...do...	nw.	Mod...	...do.....	Do.
21....	36	42	47	53	54	0.00	w.	...do...	w.	...do...	...do.....	Do.
22....	41	46	51	56	57	0.00	n.	...do...	w.	...do...	...do.....	Do.
23....	44	49	53	60	56	0.00	w.	...do...	sw.	...do...	...do.....	Do.
24....	49	53	56	62	62	0.00	w.	...do...	w.	Lt....	...do.....	Do.
25....	49	55	59	62	59	0.00	w.	...do...	w.	Mod...	...do.....	Do.
26....	46	50	55	58	59	0.00	w.	...do...	w.	...do...	...do.....	Do.
27....	54	58	59	61	62	0.02	w.	...do...	nw.	...do...	...do.....	Pt. cldy.
28....	50	52	56	59	63	0.00	w.	...do...	w.	...do...	...do.....	Clear.
29....	50	55	60	66	68	0.15	sw.	...do...	se.	Brisk..	...do.....	Pt. cldy.
30....	56	58	61	64	65	0.00	s.	...do...	s.	Mod...	...do....	Do.
31....	55	57	61	65	66	0.00	sw.	...do...	sw.	...do...	Clear....	Do.
Sum.	1,411	1,502	1,598	1,669	1,657	0.89	.....	....	.....	....	....	
Mean	45.5	48.5	51.5	53.8	53.5	.....	.....	....	.....	....	....	

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; lt.=light; pt.=partly.

TABLE 6.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, May, 1914 (selected month showing large inversions), Waldheim orchard, Highlands.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature. Station 3, base.	Temperature. Station 4, SE., 200.[1]	Temperature. Station 5, SE., 400.[1]	Precipitation at 6 p. m. (inches).	Wind. Sunrise. Dir.	Wind. Sunrise. Force.	Wind. Sunset. Dir.	Wind. Sunset. Force.	State of weather. Previous night.	State of weather. Day.
1	34	38	38	0.00	se.	Mod	se.	Lt	Clear	Clear.
2	29	42	42	0.00	se.	Lt		Calm	...do...	Do.
3	37	47	46	0.00	se.	...do...	se.	Lt	...do...	Cloudy.
4	53	52	52	0.00	se.	...do...	se.	...do...	Cloudy	Do.
5	55	53	54	0.00	nw.	Mod	nw.	Mod	...do...	Pt. cldy.
6	52	53	54	1.67	nw.	Brisk	nw.	Lt	Clear	Clear.
7	39	50	51	0.00	nw.	Mod	se.	...do...	...do...	Pt. cldy.
8	44	43	43	0.00	nw.	Brisk	nw.	Brisk	Cloudy	Do.
9	39	38	37	0.00	nw.	...do...		Calm	...do...	Do.
10	27	40	43	0.00	nw.	Lt		...do...	Clear	Clear.
11	37	53	53	0.00	nw.	...do...		...do...	...do...	Do.
12	45	57	57	0.00	nw.	...do...		...do...	...do...	Do.
13	51	55	55	0.00	nw.	...do...	nw.	Lt	...do...	Pt. cldy.
14	47	47	51	0.00	nw.	...do...	nw.	...do...	...do...	Clear.
15	40	39	39	0.00	nw.	...do...	se.	...do...	...do...	Do.
16	34	45	45	0.00	se.	...do...	se.	...do...	...do...	Pt. cldy.
17	35	47	48	0.00	se.	...do...		Calm	...do...	Cloudy.
18	43	45	46	0.00	se.	Mod		...do...	Cloudy	Pt. cldy.
19	37	44	44	0.00	se.	Brisk	se.	Lt	Clear	Do.
20	27	48	48	0.00	se.	Lt		Calm	...do...	Clear.
21	28	45	50	0.00	nw.	...do...	nw.	Lt	...do...	Do.
22	31	51	56	0.00	nw.	...do...		Calm	...do...	Do.
23	43	54	53	0.00	nw.	...do...	se.	Lt	...do...	Do.
24	42	56	60	0.00	se.	...do...	nw.	...do...	...do...	Do.
25	46	55	56	0.00	se.	...do...	se.	...do...	...do...	Do.
26	37	51	52	0.00	se.	...do...	se.	...do...	...do...	Do.
27	53	59	58	0.00	nw.	...do...	se.	...do...	...do...	Pt. cldy.
28	41	54	59	0.00	nw.	...do...		Calm	...do...	Clear.
29	44	65	64	0.29	nw.	...do...		...do...	...do...	Pt. cldy.
30	53	60	61	0.00	nw.	...do...		...do...	Cloudy	Do.
31	49	61	62	0.00	nw.	...do...	nw.	Mod	...do...	Cloudy.
Sum.	1,272	1,547	1,577	1.96						
Mean.	41.0	49.9	50.9							

[1] Direction of slope and elevation of station above base statiou.

Mod.=moderate; lt.=light; pt.=partly.

TABLE 7.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force and state of weather, November, 1914 (selected month showing large inversions) Ellijay.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature. Station 1, base.	Temperature. Station 2, N., 310.[1]	Temperature. Station 3, N., 620.[1]	Temperature. Station 4, N., 1,240.[1]	Temperature. Station 5, summit, 1,760.[1]	Precipitation at 6 p. m. (inches).	Wind. Sunrise. Dir.	Wind. Sunrise. Force.	Wind. Sunset. Dir.	Wind. Sunset. Force.	State of weather. Previous night.	State of weather. Day.
1	26	32	35	43	44	0.00	w.	Lt	w.	Lt	Clear	Clear.
2	29	35	42	47	45	0.00	w.	...do...	w.	...do...	...do...	Do.
3	33	38	43	48	49	0.00	w.	...do...	w.	...do...	...do...	Do.
4	35	42	47	53	50	0.00	w.	...do...	w.	...do...	...do...	Do.
5	33	40	48	50	46	0.00	w.	Mod	w.	Mod	...do...	Do.
6	27	33	39	45	45	0.00	w.	Lt	w.	Lt	...do...	Do.
7	30	38	43	50	53	0.00	w.	Mod	w.	Mod	...do...	Do.
8	40	47	50	49	49	0.34	w.	...do...	w.	...do...	...do...	Cloudy.
9	35	35	35	35	34	0.61	nw.	...do...	nw.	...do...	Cloudy	Clear.
10	22	22	25	28	27	0.00	w.	Lt	w.	Lt	Clear	Do.
11	25	30	35	38	39	0.00	w.	...do...	w.	...do...	...do...	Do.
12	25	30	33	42	43	0.00	w.	...do...	w.	Brisk	...do...	Do.
13	34	38	40	43	43	0.00	sw.	...do...	sw.	Lt	...do...	Cloudy.
14	37	39	46	48	48	0.25	se.	Brisk	se.	Brisk	Pt. cldy.	Do.
15	51	49	51	50	51	0.55	s.	Mod	s.	Mod	Cloudy	Do.
16	42	39	35	37	35	0.03	w.	Brisk	nw.	...do...	...do...	Clear.
17	15	14	14	15	13	0.00	nw.	Mod	nw.	...do...	Clear	Do.
18	14	15	19	21	20	0.00	w.	...do...	w.	...do...	...do...	Do.
19	22	22	25	26	25	0.00	w.	...do...	w.	...do...	...do...	Do.
20	7	4	4	1	0	0.18	nw.	Brisk	n.	Brisk	Cloudy	Do.
21	10	8	10	13	14	0.00	nw.	...do...	nw.	...do...	Clear	Do.
22	21	28	31	29	30	0.00	nw.	Lt	nw.	Lt	...do...	Do.
23	17	23	26	28	28	0.00	w.	Mod	w.	Mod	...do...	Do.
24	16	21	26	30	31	0.00	w.	Lt	w.	Lt	...do...	Do.
25	19	24	29	37	40	0.00	w.	...do...	w.	...do...	...do...	Do.
26	26	31	34	40	44	0.00	w.	...do...	w.	...do...	...do...	Do.
27	30	35	39	44	46	0.00	w.	...do...	w.	...do...	...do...	Cloudy.
28	35	39	45	44	40	0.00	se.	Brisk	se.	High	Cloudy	Do.
29	48	45	42	42	42	1.80	se.	High	se.	...do...	...do...	Do.
30	54	52	50	50	48	0.52	s.	Brisk	s.	Mod	...do...	Do.
Sum.	858	948	1,041	1,114	1,122	4.28						
Mean	28.6	31.6	35.0	37.1	37.4							

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; lt.=light; pt.=partly.

TABLE 8.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, November, 1914 (selected month showing large inversions), Waldheim orchard, Highlands.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature. Station 3, base.[1]	Temperature. Station 4, SE., 200.[1]	Temperature. Station 5, SE., 400.[1]	Precipitation at 6 p. m. (inches).	Wind. Sunrise. Dir.	Wind. Sunrise. Force.	Wind. Sunset. Dir.	Wind. Sunset. Force.	State of weather. Previous night.	State of weather. Day.
1	19	33	36	0.00	nw.	Lt	se.	Lt	Clear	Clear.
2	33	40	38	0.00	nw.	...do...	nw.	...do...	...do...	Do.
3	25	45	48	0.00	nw.	...do...	nw.	...do...	...do...	Do.
4	31	49	48	0.00	nw.	...do...		Calm	...do...	Do.
5	32	46	46	0.00	nw.	Brisk	nw.	Brisk	...do...	Do.
6	33	41	41	0.00	nw.	Lt	nw.	Lt	...do...	Do.
7	25	43	50	0.00	nw.	...do...	nw.	...do...	...do...	Do.
8	35	45	47	0.55	nw.	...do...	se.	...do...	...do...	Cloudy.
9	34	34	32	0.00	nw.	...do...	nw.	...do...	...do...	Pt. cldy
10	17	24	30	0.00	nw.	...do...	se.	...do...	Cloudy	Clear.
11	22	32	38	0.00	nw.	...do...	nw.	...do...	Clear	Do.
12	18	33	42	0.00	se.	...do...	se.	...do...	...do...	Do.
13	33	40	44	0.00	se.	...do...		Calm	...do...	Cloudy.
14	30	43	51	2.18	se.	Mod	se.	Mod	Cloudy	Do.
15	50	49	56	0.60	se.	...do...	se.	Lt	...do...	Do.
16	37	33	39	0.00	nw.	...do...	nw.	Brisk	...do...	Clear.
17	13	13	17	0.00	nw.	Lt	se.	Lt	Clear	Do.
18	7	17	23	0.00	se.	...do...		Calm	...do...	Do.
19	19	21	27	0.00	nw.	Mod	se.	Mod	...do...	Pt. cldy.
20	1	0	1	0.00	nw.	High	nw.	Lt	Cloudy	Do.
21	10	7	13	0.00	nw.	Brisk	se.	...do...	Clear	Clear.
22	28	27	32	0.00	nw.	...do...	nw.	...do...	...do...	Do.
23	27	26	29	0.00	nw.	...do...	se.	...do...	...do...	Do.
24	10	23	30	0.00	nw.	...do...	se.	...do...	...do...	Do.
25	28	29	39	0.00		Calm	se.	...do...	...do...	Do.
26	36	36	44	0.00	se.	Lt		Calm	...do...	Do.
27	25	40	49	0.00	se.	...do...	se.	Lt	...do...	Cloudy.
28	38	44	48	0.40	se.	...do...	se.	High	Cloudy	Do.
29	38	38	45	4.00	se.	High	se.	Brisk	...do...	Do.
30	46	45	50	0.20	se.	Lt		Calm	...do...	Do.
Sum.	800	996	1,123	7.93						
Mean.	26.7	33.2	37.7							

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; lt.=light; pt.=partly.

TABLE 9.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, July, 1916 (selected month showing practically no inversions), Ellijay.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature. Station 1, base.	Temperature. Station 2, N., 310.[1]	Temperature. Station 3, N., 620.[1]	Temperature. Station 4, N., 1,240.[1]	Temperature. Station 5, summit, 1,760.[1]	Precipitation at 6 p. m. (inches).	Wind. Sunrise. Dir.	Wind. Sunrise. Force.	Wind. Sunset. Dir.	Wind. Sunset. Force.	State of weather. Previous night.	State of weather. Day.
1	58	62	61	62	63	1.15		Calm	nw.	Lt	Clear	Pt. cldy.
2	61	63	61	61	61	.02		...do...	nw.	...do...	Pt. cldy.	Clear.
3	61	63	60	59	58	.00	w.	Lt	nw.	...do...	...do...	Do.
4	60	62	62	64	62	.00	w.	...do...	w.	...do...	Clear	Do.
5	58	60	60	61	59	.00	w.	Mod	nw.	...do...	...do...	Do.
6	59	62	61	62	60	.00	w.	Lt	sw.	...do...	...do...	Pt. cldy.
7	63	63	60	60	58	.06	s.	...do...	s.	...do...	Cloudy	Cloudy.
8	62	62	59	58	56	1.05	se.	Mod	se.	...do...	...do...	Do.
9	64	64	61	61	59	1.68	se.	...do...	se.	Mod	...do...	Do.
10	64	65	61	61	59	.85	s.	...do...	s.	Lt	...do...	Do.
11	69	65	62	61	59	.16	s.	...do...	s.	...do...	...do...	Do.
12	65	62	61	62	59	.75	s.	Lt	s.	...do...	...do...	Clear.
13	65	63	62	64	61	.02	s.	...do...	s.	...do...	Pt. cldy.	Pt. cldy.
14	63	60	59	62	60	.03	se.	...do...	se.	...do...	...do...	Do.
15	69	64	62	62	61	.30	s.	...do...	s.	...do...	Cloudy	Cloudy.
16	72	67	65	65	63	1.68	s.	...do...	sw.	...do...	...do...	Do.
17	67	64	63	65	63	.01		Calm	sw.	...do...	...do...	Do.
18	61	62	61	64	63	.83	s.	Lt	s.	Mod	Pt. cldy.	Pt. cldy.
19	63	62	60	62	61	1.50	s.	...do...	s.	...do...	Cloudy	Cloudy.
20	62	62	61	62	61	.26	sw.	...do...	sw.	Lt	...do...	Do.
21	64	63	62	63	60	.68	s.	...do...	sw.	...do...	...do...	Do.
22	66	64	64	63	61	.76		Calm	sw.	...do...	...do...	Do.
23	61	60	59	61	60	.00	sw.	Lt	s.	...do...	...do...	Pt. cldy.
24	60	59	60	62	61	.45	s.	...do...	s.	...do...	Clear	Do.
25	60	61	59	60	59	1.03	s.	...do...	sw.	...do...	...do...	Do.
26	58	60	59	62	59	.00	s.	...do...	sw.	...do...	Pt. cldy.	Do.
27	58	58	56	59	58	.16	s.	...do...	se.	...do...	...do...	Do.
28	60	60	60	60	59	.15		Calm	s.	...do...	...do...	Clear.
29	65	66	64	65	62	.13	s.	Lt	se.	Mod	Clear	Pt. cldy.
30	65	66	63	63	61	.00	e.	...do...	e.	...do...	Pt. cldy.	Clear.
31	62	64	62	64	62	.00	e.	...do...	e.	Lt	Clear	Do.
Sum.	1,945	1,938	1,890	1,920		13.71						
Mean	62.7	62.5	61.0	61.9	59.8							

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; Lt.=light; Pt.=partly.

TABLE 10.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, July, 1915 (selected month showing typical summer inversions), Ellijay.*

[The differences between the readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature.					Precipitation at 6 p. m. (inches).	Wind.				State of weather.	
	Station 1, base.	Station 2, N., 310.[1]	Station 3, N., 620.[1]	Station 4, N., 1,240.[1]	Station 5, summit, 1,760.[1]		Sunrise.		Sunset.		Previous night.	Day.
							Dir.	Force.	Dir.	Force.		
1...	56	58	58	59	57	0.16	w.	Mod...	w.	Mod...	Cloudy..	Cloudy.
2...	56	57	55	56	55	0.40	w.	...do...	w.	...do...	Pt. cldy.	Clear.
3...	55	58	58	60	58	0.08	w.	...do...	w.	...do...	Cloudy..	Cloudy.
4...	59	61	60	60	59	0.35	sw.	...do...	sw.	...do...	...do.....	Do.
5...	61	63	60	59	58	1.22	sw.	...do...	w.	...do...	...do.....	Do.
6...	47	51	51	52	52	0.01	nw.	...do...	nw.	...do...	Pt. cldy.	Clear.
7...	51	56	56	58	56	0.00	w.	...do...	w.	...do...	Clear....	Do.
8...	61	65	65	65	63	0.07	nw.	...do...	nw.	...do...	Cloudy..	Cloudy.
9...	54	59	58	61	61	0.00	w.	...do...	w.	...do...	Clear....	Pt. cldy.
10...	59	62	60	61	60	0.62	w.	...do...	w.	...do...	...do.....	Do.
11...	58	61	60	60	59	0.00	nw.	...do...	nw.	...do...	...do.....	Clear.
12...	61	66	67	67	64	0.00	nw.	...do...	nw.	...do...	...do.....	Do.
13...	61	65	64	65	63	0.04	w.	...do...	w.	...do...	Pt. cldy.	Pt. cldy.
14...	56	60	60	62	62	1.01	sw.	...do...	sw.	Brisk..	Clear....	Do.
15...	60	62	61	63	63	0.65	w.	...do...	w.	Mod...	...do.....	Cloudy.
16...	59	63	62	64	65	0.00	w.	...do...	w.	...do...	...do.....	Clear.
17...	58	63	64	66	63	0.00	w.	...do...	w.	...do...	...do.....	Do.
18...	58	62	62	65	63	0.00	w.	...do...	w.	...do...	...do.....	Do.
19...	60	64	63	66	66	0.06	w.	...do...	w.	...do...	...do.....	Cloudy.
20...	60	63	63	66	64	0.13	w.	...do...	w.	...do...	...do.....	Pt. cldy.
21...	55	59	58	60	57	0.00	w.	...do...	w.	...do...	...do.....	Clear.
22...	50	53	53	54	52	0.76	w.	...do...	w.	...do...	...do.....	Pt. cldy.
23...	48	50	50	53	52	0.00	ne.	...do...	w.	...do...	...do.....	Clear.
24...	51	54	54	56	55	0.00	nw.	...do...	nw.	...do...	...do.....	Do.
25...	53	56	57	59	58	0.02	w.	...do...	w.	...do...	...do.....	Do.
26...	56	58	58	61	60	0.03	ne.	...do...	ne.	...do...	...do.....	Do.
27...	57	58	59	62	62	0.00	nw.	...do...	nw.	...do...	...do.....	Do.
28...	59	60	61	66	65	0.00	w.	...do...	w.	...do...	...do.....	Do.
29...	60	61	64	66	63	0.00	w.	...do...	w.	...do...	...do.....	Do.
30...	60	62	63	68	65	0.00	w.	...do...	w.	...do...	...do.....	Do.
31...	61	62	64	68	69	0.00	w.	...do...	w.	...do...	...do.....	Do.
Sum.	1,760	1,852	1,848	1,906	1,869	5.61						
Mean	56.8	59.7	59.6	61.5	60.3	.....						

[1] Direction of slope and elevation of station above base station.

Mod. = moderate; Lt. = light; Pt. = partly.

TABLE 11.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force and state of weather, January, 1916, (selected month showing typical winter inversions), Ellijay.*

[The differences between readings at base and the respective slope stations may be seen by inspection.]

Date.	Temperature.					Precipitation at 6 p. m. (inches).	Wind.				State of weather.	
	Station 1, base.	Station 2, N., 310.[1]	Station 3, N., 620.[1]	Station 4, N., 1,240.[1]	Station 5, summit, 1,760.[1]		Sunrise.		Sunset.		Previous night.	Day.
							Dir.	Force.	Dir.	Force.		
1...	44	44	41	43	41	0.15	w.	Mod...	sw.	Mod...	Cloudy..	Pt. cldy.
2...	54	57	55	57	53	0.12	w.	...do...	w.	...do...	...do.....	Cloudy.
3...	31	35	36	38	37	0.00	nw.	...do...	nw.	...do...	Clear....	Clear.
4...	20	26	29	26	29	0.00	w.	...do...	w.	...do...	...do.....	do
5...	28	33	34	38	36	0.00	w.	Brisk .	sw.	...do...	Pt. cldy.	Cloudy.
6...	48	47	47	48	44	0.67	sw.	Mod..	sw.	...do...	Cloudy..	do
7...	49	48	49	47	44	0.96	w.	...do...	w.	...do...	...do.....	do
8...	35	36	32	33	32	0.00	nw.	...do...	nw.	...do...	...do.....	Clear.
9...	29	27	24	25	27	0.00	nw.	...do...	nw.	...do...	Clear....	do
10...	28	30	29	30	28	0.03	w.	...do...	w.	...do...	Cloudy..	Cloudy.
11...	48	49	48	49	45	0.05	w.	...do...	w.	...do...	...do.....	do
12...	53	55	54	53	49	0.09	w.	...do...	sw.	Brisk..	...do.....	do
13...	45	43	40	39	37	0.51	sw.	Brisk .	w.	Mod...	...do.....	Clear.
14...	23	23	20	18	21	0.00	w.	Mod...	w.	...do...	Pt. cldy.	Do.
15...	25	26	26	23	22	0.00	sw.	...do...	sw.	...do...	Cloudy.	Cloudy.
16...	33	31	30	29	27	0.17	w.	...do...	w.	...do...	...do.....	Do.
17...	15	13	10	8	5	0.00	nw.	Brisk .	w.	...do...	...do.....	Clear.
18...	8	7	5	7	8	0.00	nw.	Mod...	nw.	...do...	Clear....	Do.
19...	10	12	10	13	15	0.00	w.	...do...	w.	...do...	Pt. cldy.	Do.
20...	22	25	24	26	27	0.00	w.	...do...	s.	...do...	Clear....	Do.
21...	33	39	43	45	41	0.24	sw.	...do...	sw.	...do...	Cloudy..	Cloudy.
22...	51	50	48	48	43	1.14	sw.	Gale..	nw.	...do...	...do.....	Do.
23...	29	32	32	35	35	0.00	nw.	Mod..	nw.	Brisk..	Clear....	Clear.
24...	24	29	30	33	32	0.00	w.	...do...	w.	Mod...	...do.....	Do.
25...	35	39	39	41	41	0.00	sw.	...do...	s.	...do...	Pt. cldy.	Cloudy.
26...	49	50	48	49	47	0.10	s.	...do...	s.	...do...	Cloudy..	Pt. cldy.
27...	51	52	50	50	47	0.22	s.	...do...	s.	...do...	...do.....	Cloudy.
28...	49	53	52	52	49	0.04	sw.	...do...	sw.	...do...	...do.....	Do.
29...	51	53	52	53	50	0.02	sw.	...do...	sw.	...do...	...do.....	Do.
30...	53	53	50	50	47	0.00	s.	...do...	s.	...do...	...do.....	Do.
31...	56	55	52	50	47	0.10	sw.	Brisk .	sw.	Brisk .	...do.....	Do.
Sum.	1,129	1,172	1,139	1,168	1,116	4.61	.....	....	.....	....	....	....
Mean	36.4	37.8	36.7	37.7	36.0	.....	.....	....	.....	....	....	....

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; Lt.=light; Pt.=partly.

TABLE 12.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, February, 1915, (selected month showing typical winter inversions), Ellijay.*

[The differences between readings at base and the respective slope stations may be seen by inspection.]

Date.	Temperature.					Precipitation at 6 p. m. (inches).	Wind.				State of weather.	
	Station 1, base.	Station 2, N., 310.[1]	Station 3, N., 620.[1]	Station 4, N., 1,240.[1]	Station 5, summit, 1,760.[1]		Sunrise.		Sunset.		Previous night.	Day.
							Dir.	Force.	Dir.	Force.		
1...	55	52	52	50	48	1.93	s.	High..	s.	Mod..	Cloudy..	Cloudy.
2...	35	39	39	40	38	0.13	sw.	Mod..	w.	Brisk..	...do.....	Do.
3...	29	28	26	24	22	0.70	nw.	...do...	n.	Mod..	...do.....	Do.
4...	20	23	22	26	24	0.00	nw.	...do...	nw.	...do...	Clear....	Clear.
5...	29	33	32	34	32	0.35	w.	...do...	s.	...do...	Cloudy..	Cloudy.
6...	29	38	36	33	32	0.00	w.	...do...	w.	...do...	...do.....	Clear.
7...	29	27	25	23	23	0.00	nw.	Brisk .	nw.	...do...	Clear....	Do.
8...	24	24	21	18	17	0.00	nw.	Mod..	nw.	...do...	...do.....	Do.
9...	11	15	14	19	13	0.00	nw.	...do...	nw.	...do...	...do.....	Do.
10...	13	19	21	29	27	0.00	w.	...do...	w.	Lt.....	...do.....	Do.
11...	18	24	25	29	29	0.00	w.	...do...	w.	Mod..	...do.....	Do.
12...	27	33	34	38	36	0.00	w.	...do...	w.	...do...	...do.....	Do.
13...	25	32	35	41	40	0.00	s.	Lt....	s.	Lt....	...do.....	Pt. cldy.
14...	46	47	46	43	42	0.07	s.	Mod..	s.	Mod..	...do.....	Cloudy.
15...	48	47	46	45	42	0.80	s.	...do...	s.	...do...	Cloudy..	Do.
16...	29	31	30	32	30	0.00	w.	Lt....	w.	Lt....	Clear....	Pt. cldy.
17...	19	24	24	30	31	0.00	w.	...do...	w.	...do...	...do.....	Clear.
18...	20	25	27	32	32	0.00	w.	Mod..	sw.	Mod..	...do.....	Do.
19...	22	27	28	29	29	0.00	w.	...do...	w.	...do...	...do.....	Do.
20...	21	25	25	26	26	0.00	w.	...do...	w.	...do...	...do.....	Do.
21...	19	26	28	31	31	0.00	w.	...do...	w.	...do...	...do.....	Do.
22...	40	40	40	39	38	0.02	s.	...do..	s.	Mod..	Cloudy..	Cloudy.
23...	44	47	44	42	40	0.38	s.	Lt....	s.	Lt....	...do.....	Do.
24...	42	45	42	42	41	0.58	sw.	Mod..	nw.	Mod..	...do.....	Clear.
25...	32	32	29	27	25	0.00	n.	Brisk..	n.	Brisk .	...do.....	Cloudy.
26...	20	23	21	22	20	0.00	nw.	...do...	w.	Mod..	...do.....	Pt. cldy.
27...	27	30	28	31	29	0.00	w.	Mod..	w.	...do...	Clear....	Cloudy.
28...	37	38	35	34	33	0.00	w.	Lt....	w.	Lt....	Cloudy..	Do.
Sum.	810	894	875	915	873	4.96	.....	....	.....	....	....	....
Mean	28.9	31.9	31.2	32.7	31.2	.....	.....	....	.....	....	....	....

[1] Direction of slope and elevation of station above base station.

Mod.=moderate; Lt.=light; Pt.=partly.

Inversions on six selected long slopes having a vertical height of 1,000 feet or more.—Table 13 shows the frequency of inversions in the individual months and years of the research on the six long slopes having a vertical height of 1,000 feet or more—Altapass, 1,000 feet; Cane River, 1,100 feet; Ellijay, 1,760 feet; Globe, 1,000 feet; Gorge, 1,040 feet; and Tryon, 1,100 feet. The figures given in the table represent results shown by differences between minima at stations No. 1 and certain stations higher up on the slopes—usually Nos. 2, 3, and 4, at Altapass, Tryon, and Ellijay, respectively, and the summit stations, Nos. 4, 3, and 5, at Cane River, Globe, and Gorge, respectively—in each case the upper station as here indicated being approximately in the center of the thermal belt. For purposes of convenience this table has been prepared to embrace all inversions as low as 5°, and this is necessary because of the small number of large inversions registered at the observing stations at Altapass, where the lowest station, No. 1, is not really a base station, but rather on the slope several hundred feet above the valley floor.

The largest number of inversions noted in any one year on all six slopes together is 860 in 1913, and in no year did the number fall as low as 800. The largest number of inversions on a single slope for the entire four-year period is 743 at Ellijay, which has the greatest vertical height, this being an average of 186 a year, or more than one every other day. The average amount of inversion at Ellijay is 9°, and an extreme of 23° was registered on both November 13, 1913, and November 7, 1914, as shown by the differences in minima, and at 8 a. m. on those two dates inversions between Nos. 1 and 4 were, respectively, 24° and 26°, the former being the largest inversions at any hours noted at Ellijay during the research.

Altapass naturally has the smallest recorded number, 173, or 43 a year, the average range of its inversions

being 6°. On the Altapass slope the greatest inversion based upon the minima, 13°, was observed February 18, 1915, while on that day a difference of 19° was noted between Nos. 1 and 3 at 7 a.m.

All the data in Table 13 are based upon observations of minimum temperature and do not necessarily show special instances of inversion at any particular hour on any one night, as in the two cases at Altapass and Ellijay, just referred to.

While the greatest inversion at Gorge through a comparison of minima is shown in Table 13 to be 24°, there was actually an inversion of 31° between Nos. 1 and 5 on that slope at 6 a. m. November 13, 1913, this being the greatest inversion noted on any slope during the period of the research. The greatest inversion at any hour at Cane River was 30° at 8 a. m., November 21, 1913, and at the same hour January 28, 1914, while at Globe and Tryon the largest inversion at any hour was 26°, which occurred at 8 a. m. on both November 13, 1913, and February 18, 1916, at Globe and at 6 a. m. on both November 14, 1913, and February 18, 1916, at Tryon. On both dates at Globe the maximum inversion was between the base and summit stations, while at Tryon on the November date the inversion occurred between Nos. 1 and 3, and on the date in February between Nos. 1 and 2. Gorge, Cane River, and Tryon have individual instances of inversions of 24°, as shown by Table 13 and the largest average amount on all the six on all the six slopes, 10°, is found at Gorge. Large inversions at individual hours occur quite frequently at a few of the more elevated stations under the Intermediate and Cyclonic Types, and more examples will be given in detail later.

As may be seen in the table, inversions are usually most frequent in the spring and autumn months, November, May, April, and October having the largest totals for the entire period in the order given. Ellijay, which has the largest number of inversions on these six long slopes, as stated above, has a total of 83 in the four Novembers, while Cane River has an even greater number, 87, the average number for that month at both places being 21 and 22, respectively. Ellijay has its largest monthly total ln May, equalling the Cane River figure for November, 87. Gorge also has its largest number for the four-year period in May, totaling 81. On the six slopes as a whole November, 1913, and May, 1914, have the largest number for the individual months, totaling 125 and 123, respectively, and in the latter month the maximum record of 26 dates of inversion was noted at Ellijay, there being only five nights without inversions (see Table 5). Reference is made on a previous page to July, 1915, in which inversions were noted every night at Ellijay, but that statement includes all inversions, even as small as 1°, while only inversions no smaller than 5° are included in Table 13. May, 1915, a month with considerable cloudiness and storm movement, has a total of only 65 inversions on the six slopes, but even in that month 20 of these are noted at Ellijay. The month of August generally has the smallest number of inversions of 5° or more, the four-year total for that month at Cane River and Ellijay being 34 and 38, respectively, while the least number in any one August at either place is as low as 5. July, 1916, of all the individual months during the four years of record, has the smallest number of inversions, the total on the six slopes being only seven, and of these one occurred at Ellijay, none at Cane River and Globe, and four at Tryon. July, 1916, was a most unusual month in the Carolina mountain region, as heavy and even torrential rains were frequent and conditions were generally unfavorable for the occurrence of inversions.

November not only has the greatest number of inversions on all six slopes as a whole, but it also has the greatest average range, 12°, as compared with 11° for April, and 10° for May and October, and July and August have the smallest range of inversion, with only 7°.

Figure 52 is intended to supplement Table 13 and illustrates graphically the frequency of inversions, the average range, and the extreme range on five of the long slopes, Altapass being omitted for obvious reasons.

Inversions on six selected short slopes.—Table 14 presents inversion data for the six short slopes, Blantyre, Blowing Rock, Bryson, Hendersonville, Highlands, and Mount Airy, after the plan of Table 13, which gives the data for the six long slopes.

The frequency of inversions of 5° or more on the short slopes, as shown by Table 14, is much the same as on the long ones, the totals for the entire four-year period

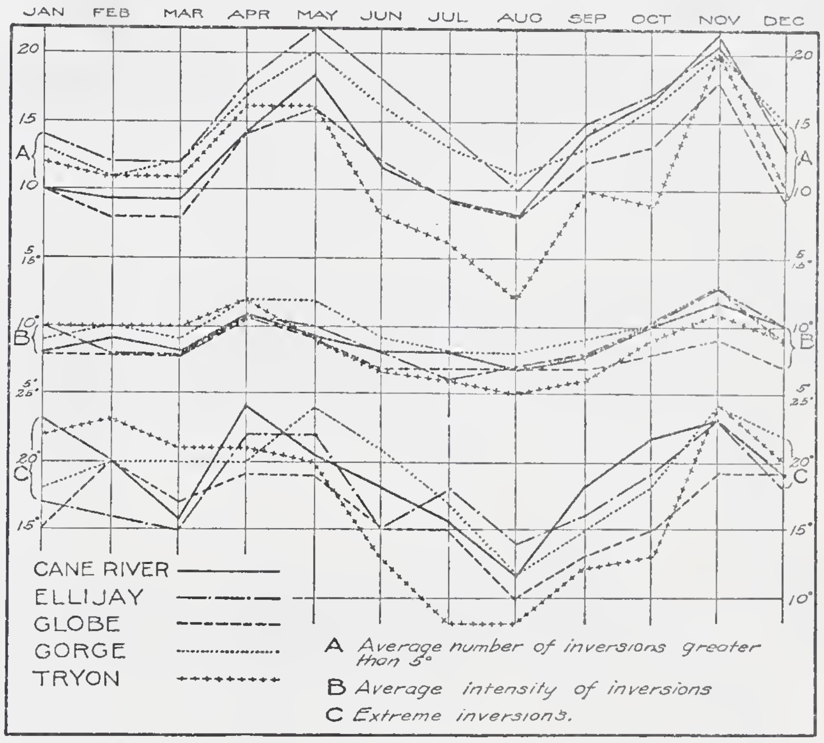

FIG. 52.—Monthly frequency, average, and extreme degrees of inversion on five selected long slopes.

being, respectively, 3,291 and 3,316, the difference being hardly appreciable. Moreover, if Altapass be omitted from the list of long slopes because of the fact that the absence of a base station there voids the comparison, it should be apparent that the frequency of these inversions of 5° or more would be even relatively greater on the long slopes.

The largest number of inversions noted in any one year on the six short slopes is 868 in 1913, and the smallest number in any one year is 778 in 1915. The largest number of inversions on a single slope is 738 in the Waldheim orchard at Highlands, as compared with 743 on the long slope at Ellijay (see Table 13). For the four-year period the largest average degree of inversion at Highlands was 11°, as compared with 9° at Ellijay. A maximum inversion of 27° occurred at Highlands on November 21, 1913, Hendersonville having on the same date an inversion of 25°. The smallest number of inversions on these short slopes for the four-year period is 423 at Mount Airy, while the smallest average range is noted at Bryson, 7°.

November leads in the number of inversions of 5° or more on the short slopes, 440, by a considerable margin, its excess over the other months being greater than that

noted in Table XIII for the long slopes. The greatest average range of inversion is also in November, 11°, while May follows with the second largest total of 372 and with the average range of 10°. August has the smallest total, 176, and the smallest average range, 7°. These figures are comparable with those given in Table 13 for the long slopes. There is, in fact, a striking similarity in the seasonable variation on the long and short slopes, the greatest frequency of inversion occurring in the months of November, May, and April, in the order named, and the least in August.

Inversions of stated amounts on six selected long slopes in the year 1914.—Table 15, supplementing Table 13, contains inversion data for the six long slopes, Altapass, Cane River, Ellijay, Globe, Gorge, and Tryon, on the 5° basis, together with additional data for 10°, 15°, and 20° for the year 1914. The figures covering inversions of 5°, which appear in Table 13 for 1914, are repeated in Table 15 in order to show the contrast between them and the arger degrees of inversion. One year only, 1914, is used in this comparison, as this will serve just as well as the entire four-year period.

As should be expected, the table shows that Altapass has but few inversions even moderately large, it having no valley floor station for purposes of comparison. It has an inversion of 10° or more only twice during the year, both instances occurring in November (Table 15), and as its largest inversion is only 11°, this slope is not found in the other two portions of the table embracing inversions of 15° and 20°. While Ellijay leads in the number of inversions of 5° or more, 196, and Gorge is second with 172, Gorge leads in the number of inversions of 10° or more with a total of 89, Ellijay following with a total of 81. Gorge also has the greatest number of inversions of 15° or more, with a total of 33, Ellijay being again second, with 31, and in the number of inversions of 20° or more Gorge is preeminently in the lead, with a total of 8, Cane River following, with 3, and Ellijay and Tyron, with 2 each. Globe does not appear in the last list, as its greatest individual inversion is only 17°.

TABLE 13.—*Total monthly and annual number of inversions of 5° or more on the 6 long slopes having a difference in elevation of 1,000 feet between base and summit stations, 1913–1916, inclusive.*

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
1913.																								
Altapass	[1]4	[1]6	..	..	[1]2	[1]5	..	..	[1]3	[1]5	..	..	[1]4	[1]6	..	..	6	6	7	12	2	5	5	18
Cane River	[1]14	[1]7	..	..	[1]7	[1]7	..	..	[1]10	[1]8	..	..	13	13	21	19	16	11	21	4	15	9	18	16
Ellijay	[1]18	[1]5	..	..	[1]8	[1]5	..	..	[1]11	[1]7	..	..	15	10	16	19	18	11	22	6	17	8	14	18
Globe	13	9	15	19	7	7	10	18	9	7	12	9	11	12	17	24	15	10	19	5	15	7	15	16
Gorge	14	10	14	17	7	10	11	17	9	8	14	9	14	14	20	24	22	13	24	5	19	10	21	14
Tryon	17	10	16	16	7	12	22	17	11	11	16	9	14	13	21	19	16	11	20	2	7	6	8	18
Total column (a). Average column (b). Greatest column (c).	80	8	..	..	38	8	..	..	53	8	..	..	71	12	21	19	92	11	24	5	75	8	21	14
1914.																								
Altapass	5	8	9	23	2	6	7	3	0	0	..	..	1	6	6	22	7	6	9	26	0	0	..	..
Cane River	10	12	23	29	9	9	15	18	[1]9	[1]8	16	16	12	9	16	23	24	11	20	22	14	8	11	29
Ellijay	16	11	17	28	11	8	11	18	12	9	15	16	17	10	18	22	26	11	18	21	19	9	13	29
Globe	10	9	13	23	8	9	13	18	6	11	17	16	9	10	15	22	21	11	16	22	14	8	11	11
Gorge	14	10	18	29	11	9	17	18	8	11	20	16	12	12	19	23	24	14	24	22	18	10	15	25
Tryon	11	11	22	29	10	10	16	18	12	10	21	16	15	10	17	22	21	9	19	26	5	6	8	21
Total column (a). Average column (b). Greatest column (c).	66	10	23	29	51	9	17	18	47	8	21	16	66	10	19	23	123	10	24	22	70	7	15	25
1915.																								
Altapass	2	5	5	5	4	8	13	18	0	0	..	..	2	6	8	21	1	5	5	10	2	5	5	18
Cane River	7	7	10	10	7	11	20	13	6	8	13	15	21	11	24	20	12	7	9	16	6	8	11	11
Ellijay	13	8	12	14	14	10	16	13	14	8	12	15	24	12	22	20	20	8	16	6	18	7	15	11
Globe	8	6	9	16	9	9	20	13	8	7	11	15	22	10	19	20	10	6	9	16	11	7	12	11
Gorge	12	8	11	5	11	10	20	13	12	9	16	26	25	12	23	20	12	9	12	17	11	8	13	20
Tryon	12	11	15	16	13	9	14	11	8	9	15	26	21	10	17	6	10	8	12	4	4	8	12	11
Total column (a). Average column (b). Greatest column (c).	54	8	15	16	58	10	20	13	48	8	16	26	115	11	24	20	65	8	16	6	52	7	15	11
1916.																								
Altapass	3	6	6	5	2	6	6	9	1	6	6	6	5	8	10	19	6	8	10	2	7	6	6	1
Cane River	7	8	12	21	13	9	14	11	12	7	11	14	12	11	15	19	21	9	19	7	15	7	12	5
Ellijay	9	8	12	21	14	10	16	11	11	8	13	14	15	11	16	19	23	11	20	7	16	7	14	5
Globe	8	8	11	4	9	9	13	11	11	7	12	14	13	9	14	12	17	10	16	10	10	7	13	5
Gorge	11	7	12	4	14	10	17	18	17	8	17	14	17	11	17	2	23	11	22	7	17	7	15	5
Tryon	6	9	14	24	14	11	23	18	13	9	14	6	14	13	18	1	19	10	18	18	14	7	13	1
Total column (a). Average column (b). Greatest column (c).	44	8	19	4	66	10	23	18	65	8	17	14	76	11	18	1	109	10	22	7	79	7	15	5

Stations.	July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
1913.																												
Altapass	0	0	..	..	4	5	6	5	5	6	7	25	5	7	10	27	10	8	12	21	2	6	7	16	47	6	12	Nov. 21.
Cane River	17	7	10	19	11	7	12	4	13	7	10	25	18	11	19	27	24	14	23	19	15	12	19	13	173	9	23	Nov. 19.
Ellijay	16	7	9	8	11	6	10	5	15	8	13	25	17	11	18	15	24	15	23	13	17	11	18	13	187	9	23	Nov. 13.
Globe	11	6	9	19	10	7	9	4	11	7	13	24	13	10	15	14	23	11	19	21	14	10	19	6	152	9	19	Dec. 6.
Gorge	17	8	11	6	10	8	11	11	10	9	13	27	14	12	17	15	23	14	24	21	18	12	22	13	177	11	24	Nov. 21.
Tryon	6	6	7	9	2	6	7	29	15	6	9	12	6	9	13	27	21	12	24	14	12	10	17	13	124	9	24	Nov. 14.
Total column (a). Average column (b). Greatest column (c).	67	7	11	6	48	7	12	4	69	7	13	24, 25, 27	73	11	19	27	125	13	24	21, 14	78	11	22	13	860	9	24	Nov. 21 and 14.
1914.																												
Altapass	3	5	7	23	1	5	5	23	5	6	9	28	3	7	9	1	6	8	11	8	1	5	5	16	34	6	11	Nov. 8.
Cane River	11	10	16	23	13	7	9	19	14	8	12	5	16	8	18	31	22	13	20	27	4	10	14	18	158	9	23	Jan. 29.
Ellijay	21	8	16	24	11	7	10	17	16	8	15	16	18	9	18	31	21	15	23	7	8	8	9	19	196	9	23	Nov. 7.
Globe	11	10	15	24	13	7	10	19	14	8	13	28	14	7	15	31	18	10	14	3	4	5	7	17	142	9	17	Mar. 16.
Gorge	13	11	17	24	16	8	12	19	15	9	14	28	15	8	14	31	20	15	24	27	6	7	12	17	172	10	24	Nov. 27.
Tryon	8	6	8	14	0	0	..	..	15	7	9	15	10	8	12	29	18	12	19	7	2	6	6	18	127	9	22	Jan. 29.
Total column (a). Average column (b). Greatest column (c).	67	8	17	24	54	6	12	19	79	8	15	16	76	8	18	31	105	13	24	27	25	7	14	18	829	9	24	Nov. 27.
1915.																												
Altapass	0	0	..	..	2	5	5	26	7	6	7	25	6	8	10	31	11	7	10	9	4	6	7	23	41	6	13	Feb. 18.
Cane River	9	8	10	30	5	7	8	24	11	7	10	27	17	12	22	13	18	10	19	1	13	8	16	27	132	9	24	Apr. 20.
Ellijay	20	6	8	17	11	7	14	7	18	8	12	26	17	10	19	31	18	12	20	5	13	9	17	31	200	9	22	Do.
Globe	14	6	9	31	8	7	9	7	10	8	13	25	13	9	13	29	18	6	13	2	6	6	8	27	137	7	20	Feb. 13.
Gorge	19	8	12	27	11	8	12	24	14	9	13	25	15	11	18	21	18	11	18	2	14	8	12	24	174	9	23	Apr. 20.
Tryon	8	6	8	30	2	6	8	8	8	6	8	19	6	9	13	26	21	12	19	1	13	11	17	27	126	9	17	Dec. 22.
Total column (a). Average column (b). Greatest column (c).	70	7	12	27	39	7	14	7	68	8	13	25	74	10	22	13	104	10	20	5	63	8	17	27, 31	810	8	24	Apr. 20.
1916.																												
Altapass	0	0	..	..	0	0	..	..	5	7	11	27	14	7	9	4	4	8	8	11	4	6	8	7	51	7	11	Sept. 27.
Cane River	0	0	4	7	5	8	10	27	17	10	18	26	17	11	19	28	23	11	19	4	20	9	18	7	162	9	19	Nov. 4.
Ellijay	1	5	5	1	5	7	9	27	12	9	16	25	17	11	16	28	20	11	19	11	17	11	18	7	160	9	20	May 1.
Globe	0	0	4	28	2	6	7	21	12	6	10	26	12	8	13	28	13	9	13	11	11	8	14	7	118	8	16	May 10.
Gorge	2	5	5	13	8	6	8	16	14	10	15	25	19	10	14	28	17	13	19	20	23	9	17	7	182	9	22	May 7.
Tryon	4	6	7	14	2	6	6	8	11	7	12	22	14	10	13	1	18	9	18	27	15	11	20	7	144	9	23	Feb. 18.
Total column (a). Average column (b). Greatest column (c).	7	6	7	14	22	7	10	27	71	8	18	26	93	10	19	28	95	11	19	4, 11, 20	90	9	20	7	817	9	23	Feb. 18.

[1] Values interpolated.
[2] Also Nov. 13, 1913.
[3] Also Nov. 21, 1914.
(a) Number of nights during which inversions of 5° or more occurred between any two stations on a slope.
(b) Average (degrees) of inversions.
(c) Amount (degrees) of greatest inversion.
(d) Date of greatest inversion.

TABLE 13.—*Total monthly and annual number of inversions of 5° or more on the 6 long slopes having a difference in elevation of 1,[illegible] feet between base and summit stations, 1913–1916, inclusive*—Continued.

Stations.	Jan. a	Jan. b	Jan. c	Feb. a	Feb. b	Feb. c	Mar. a	Mar. b	Mar. c	Apr. a	Apr. b	Apr. c	May a	May b	May c	June a	June b	June c	July a	July b	July c	Aug. a	Aug. b	Aug. c	Sept. a	Sept. b	Sept. c	Oct. a	Oct. b	Oct. c	Nov. a	Nov. b	Nov. c	Dec. a	Dec. b	Dec. c	Four-year annual a	Four-year annual b	Four-year annual c	Four-year annual d
1913–1916.																																								
Altapass	14	6	9	10	6	13	4	6	6	12	6	10	20	6	1[illegible]	11	5	6	3	5	7	7	5	6	22	6	11	[illegible]	7	[illegible]	3[illegible]	[illegible]	[illegible]	11	6	[illegible]	[illegible]	[illegible]	[illegible]	Feb. 1[illegible], 1916.
Cane River	38	8	23	36	9	20	37	8	16	58	11	24	73	9	21	5[illegible]	8	18	37	8	16	34	7	12	55	8	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	Apr. 2[illegible], 1916.
Ellijay	56	8	17	47	8	16	48	8	15	71	11	22	87	10	22	7[illegible]	8	15	58	6	1[illegible]	3[illegible]	7	14	61	8	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Nov. 7, 1914.[2]
Globe	39	8	15	33	8	20	31	8	17	55	10	19	6[illegible]	9	19	50	7	15	36	7	15	33	7	1[illegible]	47	7	13	[illegible]	[illegible]	[illegible]	72	[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]	[illegible]	[illegible]	Feb. 1[illegible], 1916.
Gorge	51	9	18	43	10	20	46	9	20	68	12	23	81	12	24	65	9	21	51	8	17	42	8	12	53	9	15	6[illegible]	10	18	7[illegible]	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	Nov. 27, 1914.
Tryon	46	10	22	41	10	23	44	10	21	64	12	21	66	9	20	30	7	13	26	6	8	6	6	8	39	6	12	[illegible]	9	1[illegible]	78	11	24	4[illegible]	[illegible]	[illegible]	[illegible]	9	24	Nov. 14, 1913.
Total, column (a); Average, column (b); Greatest, column (c)	241	8	23	213	9	23	213	8	21	328	11	24	390	10	24	276	8	21	211	7	18	16[illegible]	7	14	277	8	18	316	[illegible]	22	42[illegible]	12	24	2[illegible]	[illegible]	[illegible]	[illegible]	9	24	Nov. 14, 1913.

TABLE 14.—*Total monthly and annual number of inversions of 5° or more on six short slopes.*

Stations.	Jan. a	Jan. b	Jan. c	Jan. d	Feb. a	Feb. b	Feb. c	Feb. d	Mar. a	Mar. b	Mar. c	Mar. d	Apr. a	Apr. b	Apr. c	Apr. d
1913.																
Blantyre	14	9	15	19	10	11	16	18	12	9	15	23	12	14	21	25
Blowing Rock	6	6	7	16	3	6	6	19	5	8	10	9	8	12	17	25
Bryson	[1]8	[1]6	...	...	[1]9	[1]6	...	...	[1]10	[1]8	...	...	18	9	13	24
Hendersonville	[1]10	[1]9	...	...	[1]8	8	...	...	[1]9	[1]9	...	...	12	13	20	18
Highlands	[1]7	[1]10	...	...	[1]7	8	...	...	[1]9	[1]8	...	...	13	14	22	19
Mount Airy	8	7	10	2	3	8	10	19	3	7	8	9	6	9	12	25
Total, column (a); Average, column (b); Greatest, column (c)	53	8	15	19	40	8	16	18	48	8	15	23	69	12	22	19
1914.																
Blantyre	16	11	18	29	12	14	15	2	12	11	20	16	15	10	15	23
Blowing Rock	8	7	11	23	3	8	10	27	4	6	7	16	5	9	12	18
Bryson	[1]16	[1]7	...	...	9	8	10	2	8	8	10	16	17	8	11	23
Hendersonville	14	10	15	29	8	11	13	2	11	9	16	16	13	11	18	28
Highlands	9	12	17	14	7	10	12	27	7	11	21	16	13	13	22	22
Mount Airy	7	9	13	29	6	8	10	3	7	7	10	16	6	8	12	22
Total, column (a); Average, column (b); Greatest, column (c)	70	10	18	29	45	10	15	2	49	9	21	16	69	10	22	22
1915.																
Blantyre	12	9	15	16	9	10	16	21	13	8	12	15	23	11	21	20
Blowing Rock	5	5	6	14	8	9	14	13	5	7	10	16	16	9	14	27
Bryson	4	8	10	5	6	8	10	13	10	7	9	4	21	8	12	20
Hendersonville	11	8	14	14	9	11	15	13	9	8	12	29	25	11	24	20
Highlands	[1]12	[1]8	...	...	10	11	20	18	5	7	11	14	21	13	25	20
Mount Airy	3	8	9	16	4	7	10	21	5	6	7	26	10	8	15	26
Total, column (a); Average, column (b); Greatest, column (c)	17	8	15	16	46	10	20	18	47	7	12	15	119	10	25	20
1916.																
Blantyre	6	9	14	21	13	11	17	18	15	10	17	14	20	11	16	11
Blowing Rock	6	8	13	21	5	8	11	11	7	8	12	11	11	9	12	19
Bryson	9	8	11	5	9	8	16	18	9	9	12	14	16	9	16	14
Hendersonville	7	9	13	14	13	10	17	11	15	12	11	6	16	10	21	19
Highlands	8	10	21	4	10	9	16	11	12	9	15	31	14	12	22	19
Mount Airy	3	7	8	4	8	7	12	18	4	6	7	21	6	6	8	23
Total, column (a); Average, column (b); Greatest, column (c)	3[illegible]	9	21	4	58	9	17	18	62	9	17	14	83	10	22	1[illegible]

Stations.	May a	May b	May c	May d	June a	June b	June c	June d	July a	July b	July c	July d	Aug. a	Aug. b	Aug. c	Aug. d
1913.																
Blantyre	17	10	17	5	9	8	11	14	10	6	9	18	5	5	6	28
Blowing Rock	13	10	14	1	12	8	13	18	10	7	11	8	11	7	9	4
Bryson	15	9	15	4	8	7	11	15	2	10	13	7	3	5	5	25
Hendersonville	17	12	24	4	17	7	11	15	8	6	8	8	6	6	7	26
Highlands	19	13	25	4	23	12	22	16	18	10	18	8	19	9	15	5
Mount Airy	14	10	17	3	11	7	12	16	5	6	10	8	8	7	8	17
Total, column (a); Average, column (b); Greatest, column (c)	95	11	25	4	80	9	22	16	53	8	18	8	52	7	15	5
1914.																
Blantyre	21	11	16	23	16	7	11	21	13	7	12	13	4	5	6	19
Blowing Rock	18	10	18	27	9	6	8	12	15	8	12	23	12	8	15	20
Bryson	20	8	12	26	6	6	9	3	2	5	5	8	1	5	5	24
Hendersonville	22	12	18	23	16	8	12	29	13	8	11	26	6	5	6	19
Highlands	20	15	25	22	21	11	19	30	25	10	22	24	19	10	15	18
Mount Airy	16	9	13	28	10	6	8	20	15	7	10	12	7	7	9	19
Total, column (a); Average, column (b); Greatest, column (c)	120	11	25	22	78	7	19	30	83	8	22	24	49	8	15	18
1915.																
Blantyre	15	7	13	16	3	6	7	27	5	6	7	30	5	7	8	8
Blowing Rock	4	6	7	16	9	7	10	6	14	6	9	15	6	6	9	8
Bryson	5	7	10	16	0	...	...	...	0	...	...	...	1	5	5	7
Hendersonville	13	9	14	16	12	6	14	11	14	7	10	29	6	7	9	7
Highlands	16	9	15	6	13	9	16	11	26	10	15	28	17	9	19	7
Mount Airy	11	6	8	2	8	6	8	27	9	7	9	15	6	6	8	7
Total, column (a); Average, column (b); Greatest, column (c)	61	8	15	6	45	7	16	11	68	8	15	28	41	7	19	7
1916.																
Blantyre	19	11	2[illegible]	1[illegible]	9	6	11	1	1	5	5	4	2	7	8	28
Blowing Rock	12	9	18	7	11	6	9	14	8	6	8	1	7	7	8	19
Bryson	17	8	12	10	2	6	6	2	1	5	5	6	0	...	...	...
Hendersonville	19	10	19	10	17	8	15	10	0	...	...	...	6	6	11	28
Highlands	16	1[illegible]	25	7	18	10	19	5	8	6	8	1	14	8	14	21
Mount Airy	10	8	10	10	12	6	8	5	1	6	6	5	5	8	10	26
Total, column (a); Average, column (b); Greatest, column (c)	9[illegible]	11	2[illegible]	7	69	8	19	5	19	6	8	1	34	7	14	21

Stations.	Sept. a	Sept. b	Sept. c	Sept. d	Oct. a	Oct. b	Oct. c	Oct. d	Nov. a	Nov. b	Nov. c	Nov. d	Dec. a	Dec. b	Dec. c	Dec. d	Annual a	Annual b	Annual c	Annual d
1913.																				
Blantyre	10	6	9	25	13	11	16	13	25	14	2[illegible]	13	19	1[illegible]	1[illegible]	1[illegible]	1[illegible]	9	[illegible]	Apr. 2[illegible]
Blowing Rock	13	8	13	24	8	10	16	5	19	11	18	2[illegible]	14	[illegible]	[illegible]	6	1[illegible]	[illegible]	[illegible]	Nov. 2[illegible]
Bryson	7	6	9	25	18	8	12	27	[1]20	[1]12			[1]16	[1]10		..	134	8	1[illegible]	May 4
Hendersonville	12	8	13	25	14	11	19	27	23	13	2[illegible]	21	16	1[illegible]	1[illegible]	17	1[illegible]	9	[illegible]	Nov. 2[illegible]
Highlands	15	13	22	24	18	13	23	6	23	16	27	21	2[illegible]	14	[illegible]	[illegible]	191	12	2[illegible]	D[illegible]
Mount Airy	13	7	11	26	10	9	15	5	18	9	14	7	14	7	11	14	15[illegible]	8	17	May [illegible]
Total, column (a); Average, column (b); Greatest, column (c)	70	8	22	24	81	10	23	6	128	1[illegible]	27	21	99	1[illegible]	23	5	[illegible]	[illegible]	[illegible]	Nov. 2[illegible]
1914.																				
Blantyre	14	7	13	7	11	8	16	1	21	13	18	7	1[illegible]	7	1[illegible]	17	[illegible]	[illegible]	[illegible]	Mar. 1[illegible]
Blowing Rock	14	8	11	27	10	8	14	22	16	9	17	14	[illegible]	[illegible]	12	2[illegible]	1[illegible]	8	1[illegible]	May 2[illegible]
Bryson	1	6	6	6	5	6	10	31	20	10	17	28	4	[illegible]	7	1[illegible]	[illegible]	[illegible]	[illegible]	Nov. 2[illegible]
Hendersonville	12	7	11	6	13	8	12	31	2[illegible]	11	18	7	[illegible]	8	12	17	1[illegible]	[illegible]	[illegible]	May 2[illegible]
Highlands	18	10	17	5	16	10	17	31	22	14	2[illegible]	7	14	1[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	May 2[illegible]
Mount Airy	11	6	9	27	11	6	10	31	15	9	17	3	4	[illegible]	11	24	11[illegible]	8	1[illegible]	Nov. [illegible]
Total, column (a); Average, column (b); Greatest, column (c)	70	8	17	5	66	8	17	31	114	11	2[illegible]	7	[illegible]	8	1[illegible]	12	[illegible]	9	2[illegible]	May 2[illegible].
1915.																				
Blantyre	6	8	10	23	11	10	18	31	18	11	17	5	1[illegible]	8	11	4	[illegible]	[illegible]	[illegible]	Apr. 2[illegible]
Blowing Rock	15	7	12	25	13	10	19	31	17	8	12	8	[illegible]	[illegible]	[illegible]	11	117	7	[illegible]	Oct. 1[illegible]
Bryson	0	...	...	...	9	8	14	30	18	8	14	2[illegible]	11	6	[illegible]	4	[illegible]	[illegible]	[illegible]	Nov. 2[illegible]
Hendersonville	15	8	17	25	15	11	21	31	19	11	2[illegible]	5	14	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	Apr. [illegible]
Highlands	20	11	20	25	16	15	22	31	17	12	18	17	9	1[illegible]	15	[illegible]	1[illegible]	1[illegible]	[illegible]	D[illegible]
Mount Airy	7	7	10	25	12	8	13	31	13	7	10	7	[illegible]	7	8	2[illegible]	9	7	[illegible]	Apr. 2[illegible]
Total, column (a); Average, column (b); Greatest, column (c)	63	9	20	25	76	11	22	31	102	1[illegible]	2[illegible]	4	6[illegible]	8	1[illegible]	11	77[illegible]	9	2[illegible]	Apr. 2[illegible]
1916.																				
Blantyre	7	9	11	28	16	9	14	29	18	11	1[illegible]	2[illegible]	17	[illegible]	[illegible]	7	14[illegible]	[illegible]	[illegible]	May 1[illegible]
Blowing Rock	14	8	15	26	11	8	1[illegible]	8	1[illegible]	8	1[illegible]	1[illegible]	11	7	1[illegible]	7	[illegible]	[illegible]	[illegible]	May 7
Bryson	2	8	9	26	10	7	12	2[illegible]	19	8	12	2[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	1[illegible]	[illegible]	[illegible]	Jan. 1[illegible]
Hendersonville	16	9	17	22	18	10	1[illegible]	1[illegible]	16	12	2[illegible]	4	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Dec. 7
Highlands	19	11	17	26	18	13	22	28	17	14	2[illegible]	[illegible]	17	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	May 7
Mount Airy	14	8	1[illegible]	26	17	8	13	12	1[illegible]	8	11	1[illegible]	1[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	Sept. 2[illegible]
Total, column (a); Average, column (b); Greatest, column (c)	72	9	17	26	9[illegible]	9	22	28	9[illegible]	1[illegible]	2[illegible]	4	6[illegible]	[illegible]	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	May 7

Stations	Jan a	Jan b	Jan c	Feb a	Feb b	Feb c	Mar a	Mar b	Mar c	Apr a	Apr b	Apr c	May a	May b	May c	June a	June b	June c	July a	July b	July c	Aug a	Aug b	Aug c	Sept a	Sept b	Sept c	Oct a	Oct b	Oct c	Nov a	Nov b	Nov c	Dec a	Dec b	Dec c	Four-year annual a	Four-year annual b	Four-year annual c	Four-year annual d
1913–1916.																																								
Blantyre	48	9	18	44	12	17	[illegible]	10	2[illegible]	7[illegible]	12	21	7[illegible]	10	2[illegible]	37	7	11	29	6	12	16	6	8	37	8	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Apr. 2[illegible], 1915.[2]
Blowing Rock	2[illegible]	6	1[illegible]	19	8	14	21	7	12	4[illegible]	[illegible]	17	47	[illegible]	18	41	7	17	47	7	12	[illegible]	7	1[illegible]	56	8	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bryson	[illegible]	7	11	[illegible]	8	1[illegible]	47	8	12	72	8	1[illegible]	47	8	1[illegible]	16	6	11	[illegible]	7	1[illegible]	[illegible]	[illegible]	[illegible]	19	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hendersonville	42	9	1[illegible]	[illegible]	10	17	44	9	1[illegible]	6[illegible]	11	24	71	11	24	62	7	12	[illegible]	7	11	24	6	11	55	8	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Highlands	[illegible]	11	21	34	10	20	73	9	21	64	1[illegible]	[illegible]	71	1[illegible]	2[illegible]	7[illegible]	10	2[illegible]	77	[illegible]	[illegible]	[illegible]	9	19	72	11	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mount Airy	21	8	12	[illegible]	8	12	19	6	11	2[illegible]	8	1[illegible]	41	8	17	41	6	12	[illegible]	6	10	26	7	1[illegible]	45	7	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total, column (a); Average, column (b); Greatest, column (c)	204	9	21	18[illegible]	9	20	2[illegible]	8	21	340	10	2[illegible]	[illegible]	10	2[illegible]	272	8	21	223	8	2[illegible]	178	7	19	22[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Nov. 1[illegible], 1913.

[1] Values interpolated.
[2] Also Apr. 20, 1915.
(a) Number of nights during which inversions of 5° or more occurred between any two stations on a slope.
(b) Average [illegible] of inversions.
(c) [illegible]
(d) Date of greatest inversion.

TABLE 15.—*Total monthly and annual number of inversions of 5°, 10°, 15°, and 20° on six long slopes having a difference in elevation of 1,000 feet between base and summit stations, 1914.*

INVERSIONS OF 5° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.				July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Altapass	5	8	9	23	2	6	7	3	0	0	..	..	1	6	6	22	7	6	9	26	0	0	..	..	3	5	7	23	1	5	5	23	5	6	9	28	3	7	9	1	6	8	11	8	1	5	5	16	34	6	11	Nov. 8.
Cane River	10	12	23	29	9	9	15	18	[1] 9	[1] 8	16	16	12	9	16	23	24	11	20	22	14	8	11	29	11	10	16	23	13	7	9	19	14	8	12	5	16	8	18	31	22	13	20	27	4	10	14	18	158	9	23	Jan. 29.
Ellijay	16	11	17	28	11	8	11	18	12	9	15	16	17	10	18	22	26	11	18	21	19	9	13	29	21	8	16	24	11	7	10	17	16	8	15	16	18	9	18	31	21	15	23	7	8	8	9	19	196	9	23	Nov. 7.
Globe	10	9	13	23	8	9	13	18	6	11	17	16	9	10	15	22	21	11	16	22	14	8	11	11	11	10	15	24	13	7	10	19	14	8	13	28	14	7	15	31	18	10	14	3	4	5	7	17	142	9	17	Mar. 16.
Gorge	14	10	18	29	11	9	17	18	8	11	20	16	12	12	19	23	24	14	24	22	18	10	15	25	13	11	17	24	16	8	12	19	15	9	14	28	15	8	14	31	20	15	24	27	6	7	12	17	172	10	24	Nov. 27.
Tryon	11	11	22	29	10	10	16	18	12	10	21	16	15	10	17	22	21	9	19	26	5	6	8	21	8	6	8	14	0	..	..	..	15	7	9	15	10	8	12	29	18	12	19	7	2	6	6	18	127	9	22	Jan. 29.
Total, column (a); Average, column (b); Greatest, column (c)	66	10	23	..	51	9	17	..	47	8	21	..	66	10	19	..	123	10	24	..	70	7	15	..	67	8	17	..	54	6	12	..	79	8	15	...	76	8	18	..	105	13	24	.....	25	7	14	...	829	9	24	

INVERSIONS OF 10° OF MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.				July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Altapass	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	10	11	8	..	..	..	..	2	10	11	Nov. 8.
Cane River	7	15	23	29	2	12	15	18	2	14	16	16	5	13	16	23	16	13	20	22	3	10	11	29	8	12	16	23	..	..	..	..	3	11	12	5	3	12	18	31	15	14	20	27	2	13	14	18	66	13	23	Jan. 29.
Ellijay	10	13	17	28	2	11	11	18	6	13	18	16	5	16	18	22	14	14	18	21	9	11	13	29	6	13	16	24	2	10	10	17	6	12	15	16	3	5	18	31	18	16	23	7	..	..	..	..	81	12	23	Nov. 7.
Globe	4	12	13	23	5	11	13	18	4	12	17	16	5	13	15	22	11	13	16	22	3	10	11	11	7	12	15	24	2	10	10	19	3	11	13	28	1	15	15	31	11	12	14	3	..	..	..	..	56	12	17	Mar. 16.
Gorge	6	14	18	29	5	13	17	18	3	16	20	16	8	14	19	23	20	15	24	22	12	12	15	25	8	14	17	24	3	12	12	19	5	13	14	28	1	14	14	31	17	16	24	27	1	12	12	17	89	14	24	Nov. 27.
Tryon	6	15	22	29	5	13	16	18	5	15	21	16	7	13	17	22	8	13	19	26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	12	12	29	11	14	19	7	..	..	..	..	44	13	22	Jan. 29.
Total, column (a); Average, column (b); Greatest, column (c)	33	14	23	..	19	12	17	..	20	14	21	..	30	14	19	..	69	14	24	..	27	11	15	..	29	13	17	..	7	11	12	..	17	12	15	...	10	12	18	..	4	16	24	.....	3	12	14	...	338	12	24	

INVERSIONS OF 15° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.				July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Cane River	3	19	23	29	1	15	15	18	1	16	16	16	1	16	16	23	6	17	20	22	..	..	..	..	1	16	16	23	..	..	..	..	..	..	..	..	1	18	18	31	9	18	20	27	..	..	..	..	23	17	23	Jan. 29.
Ellijay	3	16	17	28	..	..	..	..	1	18	18	16	4	16	18	22	6	16	18	21	..	..	..	..	2	16	16	24	..	..	..	..	1	15	15	16	2	16	18	31	12	18	23	7	..	..	..	..	31	16	23	Nov. 7.
Globe	..	..	..	..	..	..	..	..	1	17	17	16	1	15	15	22	5	16	16	22	..	..	..	..	1	15	15	24	..	..	..	..	..	..	..	..	1	15	15	31	..	..	..	..	..	..	..	..	9	16	17	Mar. 16.
Gorge	1	18	18	29	2	16	17	18	1	20	20	16	4	18	19	23	10	19	24	22	1	15	15	25	3	16	17	24	..	..	..	..	..	..	..	..	..	..	..	..	11	18	24	27	..	..	..	..	33	18	24	May 22.
Tryon	3	17	22	29	2	16	16	18	3	17	21	16	2	16	17	22	2	19	19	26	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	16	19	7	..	..	..	..	19	17	22	Jan. 29.
Total, column (a); Average, column (b); Greatest, column (c)	10	17	23	..	5	16	17	..	7	18	21	..	12	16	19	..	29	17	24	..	1	15	15	..	7	16	17	..	..	..	..	..	1	15	15	...	4	16	18	..	39	17	24	.....	..	..	..	...	115	17	24	

INVERSIONS OF 20° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.				July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Cane River	1	23	23	29	..	..	..	..	..	..	..	..	..	..	..	..	1	20	20	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	20	20	27	..	..	..	..	3	21	23	Jan. 29.
Ellijay	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	22	23	7	..	..	..	..	2	22	23	Nov. 7.
Gorge	..	..	..	..	..	..	..	..	1	20	20	16	..	..	..	..	3	23	24	22	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	21	24	27	..	..	..	..	8	21	24	Nov. 27.
Tryon	1	22	22	29	..	..	..	..	1	21	21	16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	22	22	Jan. 29.
Total, column (a); Average, column (b); Greatest, column (c)	2	22	23	..	..	..	..	..	2	20	21	..	..	..	..	..	4	22	24	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	21	24	27	..	..	..	..	15	22	24	

[1] Values interpolated.

(a) Number of nights during which inversions of 5°, 10°, 15°, and 20° or more occurred between any two stations of slope.
(b) Average (degrees) of inversion.
(c) Amount in degrees of greatest inversion.
(d) Greatest inversion, date of.

TABLE 16.—*Total monthly and annual number of inversions of 5°, 10°, 15°, and 20° on six short slopes, 1914.*

INVERSIONS OF 5° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	16	11	18	29	12	14	15	2	12	11	20	16	15	10	15	23	24	11	16	23	16	7	11	24
Blowing Rock	8	7	11	23	3	8	10	27	4	6	7	16	5	9	12	18	18	10	18	27	9	6	8	12
Bryson	[1]16	[1]7	..	..	9	8	10	2	8	8	10	16	17	8	11	23	20	8	12	26	6	6	9	3
Hendersonville	14	10	15	29	8	11	13	2	11	9	16	16	13	11	18	28	22	12	18	23	16	8	12	29
Highlands	9	12	17	14	7	10	12	27	7	11	21	16	13	13	22	22	20	15	25	22	21	11	19	30
Mount Airy	7	9	13	29	6	8	10	3	7	7	10	16	6	8	12	22	16	9	13	28	10	6	8	29
Total, column (a); Average, column (b); Greatest, column (c)	70	10	18	..	45	10	15	..	49	9	21	..	69	10	22	..	120	11	25	..	78	7	19	..

Stations.	July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	13	7	12	13	4	5	6	19	14	7	13	7	11	8	16	1	21	13	18	7	10	7	13	17	168	9	20	Mar. 16.
Blowing Rock	15	8	12	23	12	8	15	20	14	8	11	27	10	8	14	22	16	9	15	14	2	9	12	28	116	8	18	May 27.
Bryson	2	5	5	8	1	5	5	24	1	6	6	6	5	6	10	31	20	10	17	28	4	6	7	18	109	7	17	Nov. 28.
Hendersonville	13	8	11	26	6	5	6	19	12	7	11	6	13	8	12	31	20	11	18	7	5	8	12	17	153	9	18	May 23.
Highlands	25	10	22	24	19	10	15	18	18	10	17	5	16	10	17	31	22	14	25	7	14	10	15	12	191	11	25	May 22.
Mount Airy	15	7	10	12	7	7	9	19	11	6	9	27	11	6	10	31	15	9	17	3	4	9	11	24	115	8	17	Nov. 3.
Total, column (a); Average, column (b); Greatest, column (c)	83	8	22	..	49	8	15	..	70	8	17	...	66	8	17	..	114	11	25	.....	39	8	15	...	852	9	25	

INVERSIONS OF 10° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	8	14	18	29	6	12	15	2	7	14	20	16	9	12	15	23	19	13	16	23	2	11	11	24
Blowing Rock	1	11	11	23	1	10	10	27	..	..	..	..	3	11	12	18	9	13	18	27	..	..	..	..
Bryson	..	..	..	..	1	10	10	2	2	10	10	16	5	11	11	23	3	11	12	26	..	..	..	..
Hendersonville	8	13	15	29	7	11	13	2	4	12	16	16	9	13	18	28	19	13	18	23	2	11	12	29
Highlands	6	13	17	14	4	11	12	27	4	15	21	16	9	15	22	22	18	15	25	22	12	15	19	30
Mount Airy	2	12	13	29	1	10	10	3	2	10	10	16	1	12	12	22	7	11	13	28	..	..	..	..
Total, column (a); Average, column (b); Greatest, column (c)	25	13	18	..	20	11	15	..	19	12	21	..	36	12	22	..	75	13	25	..	16	12	19	..

Stations.	July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	4	11	12	13	..	..	..	..	2	12	13	7	3	13	16	1	19	14	18	17	2	12	13	17	81	12	18	Nov. 17.
Blowing Rock	3	11	12	23	3	12	15	20	1	11	11	27	4	12	14	22	6	13	15	14	1	12	12	28	32	12	18	May 27.
Bryson	..	..	..	..	..	..	..	..	..	..	..	...	1	10	10	31	11	11	17	28	..	..	..	..	23	10	17	Nov. 28.
Hendersonville	4	11	11	26	..	..	..	..	2	10	11	6	3	11	12	31	13	14	18	7	1	12	12	17	72	11	18	Nov. 7.
Highlands	9	16	22	24	10	12	15	18	12	12	17	5	9	13	17	31	16	17	25	7	6	12	15	12	115	14	25	Nov. 7.
Mount Airy	1	10	10	12	..	..	..	..	..	..	..	...	..	..	..	..	1	17	17	3	..	..	..	..	15	12	17	Nov. 3.
Total, column (a); Average, column (b); Greatest, column (c)	21	12	22	..	13	12	15	..	17	11	17	...	20	12	17	..	66	14	25	.....	10	12	15	...	338	12	25	

INVERSIONS OF 15° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	2	17	18	29	1	15	15	2	2	18	20	16	2	15	15	23	6	15	16	23	..	..	..	..
Blowing Rock	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	17	18	27	..	..	..	..
Bryson	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hendersonville	2	15	15	29	..	..	..	..	1	16	16	16	3	16	18	28	3	17	18	23	..	..	..	..
Highlands	3	16	17	14	..	..	..	..	1	21	21	16	6	17	22	22	9	19	25	22	6	16	19	30
Mount Airy	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total, column (a); Average, column (b); Greatest, column (c.)	7	16	18	..	1	15	15	..	4	18	20	..	11	16	22	..	20	17	25	..	6	16	19	..

Stations.	July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	..	..	..	..	..	..	..	..	..	..	..	...	1	16	16	1	8	16	18	7	..	..	..	...	22	16	20	Mar. 16.
Blowing Rock	..	..	..	..	1	15	15	20	..	..	..	...	..	..	..	..	1	15	15	14	..	..	..	...	4	16	18	May 27.
Bryson	..	..	..	..	..	..	..	..	..	..	..	...	..	..	..	..	1	17	17	28	..	..	..	...	1	17	17	Nov. 28.
Hendersonville	..	..	..	..	..	..	..	..	..	..	..	...	..	..	..	..	5	16	18	7	..	..	..	...	14	16	18	May 23.
Highlands	6	18	22	24	2	15	15	18	1	17	17	5	2	16	17	31	9	21	25	7	1	15	15	12	46	17	25	Nov. 7.
Mount Airy	..	..	..	..	..	..	..	..	..	..	..	...	..	..	..	..	1	17	17	3	..	..	..	...	1	17	17	Nov. 3.
Total, column (a); Average, column (b); Greatest, column (c.)	6	18	22	..	3	15	15	..	1	17	17	...	3	16	17	..	25	102	25	.....	1	15	15	...	88	16	25	

INVERSIONS OF 20° OR MORE.

Stations.	Jan.				Feb.				Mar.				Apr.				May.				June.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	..	..	..	..	..	..	..	..	1	20	20	16	..	..	..	..	..	..	..	..	..	..	..	..
Highlands	..	..	..	..	..	..	..	..	1	21	21	16	1	22	22	22	4	24	25	22	..	..	..	..
Total, column (a); Average, column (b); Greatest, column (c)	..	..	..	..	..	..	..	..	2	20	21	..	1	22	22	..	4	24	25	..	..	..	..	..

Stations.	July.				Aug.				Sept.				Oct.				Nov.				Dec.				Annual.			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Blantyre	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.....	..	..	..	...	1	20	20	Mar. 16.
Highlands	1	22	22	24	..	..	..	..	..	..	..	..	..	..	..	..	6	23	25	7	..	..	..	...	13	22	25	May 22.
Total, column (a); Average, column (b); Greatest, column (c)	1	22	22	..	..	..	..	..	..	..	..	..	..	..	..	..	6	23	25	.....	..	..	..	...	14	21	25	

[1] Values interpolated.

(a) Number of nights during which inversions of 5°, 10°, 15°, and 20° or more occurred between any two stations on slope.
(b) Average (degrees) of inversion.
(c) Amount (degrees) of greatest inversion.
(d) Date of greatest inversion.

The table shows that November, May, and April have the greatest number of inversions of the larger amounts in the order named, especially those of 15° or more. The colder months of January, February, and March are also well represented in the portions of the table showing the larger inversions; August has practically no large inversions, and Ellijay, Gorge, and Globe are the only slopes in that month having amounts equaling 10°, no slope having inversions then of 15° or more.

In the discussion of Table 2a under the subject of "Average minimum temperature" we found many cases of pronounced inversions during the selected clear periods of May, 1913, and November, 1916, and that, as a rule, the largest inversions occurred in the May period; but in Table 13, containing the number of instances of inversions of 5° or more on the six longest slopes, we find that, during the four-year period from 1913 to 1916 not only do the greatest number of inversions occur in November, but also the greatest range of inversion. However, in two out of the four years, 1914 and 1916, the number of inversions in May exceeds those in November, while in every year of the four the average degree of inversion in November either equals or exceeds the average in May. During a long period of years there would doubtless be very little difference in the frequency or the range between the two months.

Inversions of stated amounts on six selected short slopes in the year 1914.—Table 16 supplements Table 14, just as Table 15 supplements Table 13, and, moreover, in presenting data for varying amounts of inversion on six short slopes, serves as a comparison with Table 15.

Table 16 contains the data for 1914 for Blantyre, the Flat Top orchard at Blowing Rock, Bryson, Hendersonville, the Waldheim orchard at Highlands, and

Mount Airy, ranging in vertical height, base to summit, from 350 feet at Blowing Rock to 750 feet at Hendersonville. The figures for these shorter slopes in Tables 14 and 16 generally represent inversions between the base and summit stations, while the figures for the long slopes shown in the other tables usually represent inversions between the base and certain slope stations at Altapass, Ellijay, and Tryon and between the base and summit stations at Cane River, Globe, and Gorge.

On the short slopes under discussion, for the year 1914 the Waldheim orchard at Highlands stands out preeminently as having the largest number of inversions of stated amounts, 5°, 10°, 15°, and 20°, and this record confirms previous statements made regarding that slope. While the total number of inversions of 5° for the year 1914 does not quite equal the number noted in the same year at Ellijay, 196, as shown in Table 15, the frequency of the larger inversions is always greater at Highlands because of the abnormally low minima at the base station, totaling 115 with 10° or more, 46 with 15° or more, and 13 with 20° or more. During inversions there are, in fact, often extraordinary differences between the temperature at the base station and No. 4, 200 feet above, and at times even greater differences between the base and the summit station, No. 5.

Blantyre is the only other short slope which has an inversion of 20° or more, ranking next to Highlands in this respect, as well as in the number of inversions of 5°, 10°, and 15°. Reference has been made frequently to the character of the exposure of the base station at Blantyre, the French Broad River valley at that point being a vast frost pocket, and it is because of the low minima at No. 1 that the inversions there are comparatively large and frequent. Generally speaking, so far as large inversions of 15° or 20° are concerned, if Highlands were excepted the number would be considerably less on the short slopes than on the long ones.

Taking the six short slopes as a whole, May leads in the number of inversions of 5° and 10° or more, with November second, while November leads in the number of 15° or more and 20° or more. On the long slopes (Table 15) May leads only in the smaller inversions of 5° or more, the month of November leading with the larger inversions.

Highlands has the largest number of the smaller inversions in the month of July, 25, November following with 22, June with 21, and May with 20; in the larger inversions of 10°, 15°, and 20°, November and May easily lead. It is intersting to note that the Waldheim orchard at Highlands has the greatest elevation above sea level, not only of the six slopes included in Tables 14 and 16, but also of all the slopes in the entire research.

Effects of variation in vapor pressure, relative humidity, and temperature, upon degree of inversion.—It has been shown in previous chapters that the frequency of and range in inversion is greatest during the spring and autumn months, mainly because in those periods of the year in the Carolina mountains clear weather predominates to a much greater degree than in other seasons, areas of high pressure often remaining for long periods. However, the range of inversion is also dependent upon other causes—namely, vapor pressure, relative humidity, temperature, wind direction and velocity, and soil cover.

Satisfactory data for vapor pressure and relative humidity covering the period of the research for the various orchard stations are not available, and in making a comparison between degree of inversion and atmospheric moisture it has become necessary to use the humidity observations at the regular station of the Weather Bureau at Asheville, located in the heart of the mountain region. These figures cannot be expected to give the exact data for the various sections; nevertheless, they may be considered to be approximately correct for the stations in the immediate vicinity having the same elevation above sea level, as Hendersonville, Blantyre, and Cane River.

Figure 53 presents in graphic form the variation in relative humdity and vapor pressure at nightfall for the Asheville Weather Bureau station and the average range of inversion the following morning on the slopes at Asheville, Hendersonville, Blantyre, and Cane River in certain selected clear periods of inversion weather for the 12 months of the year, including the selected May and November periods appearing in Table 2a. It is apparent that there is a striking inverse relation between the relative humidity and average range of inversion, the maximum degree of inversion being noted in May

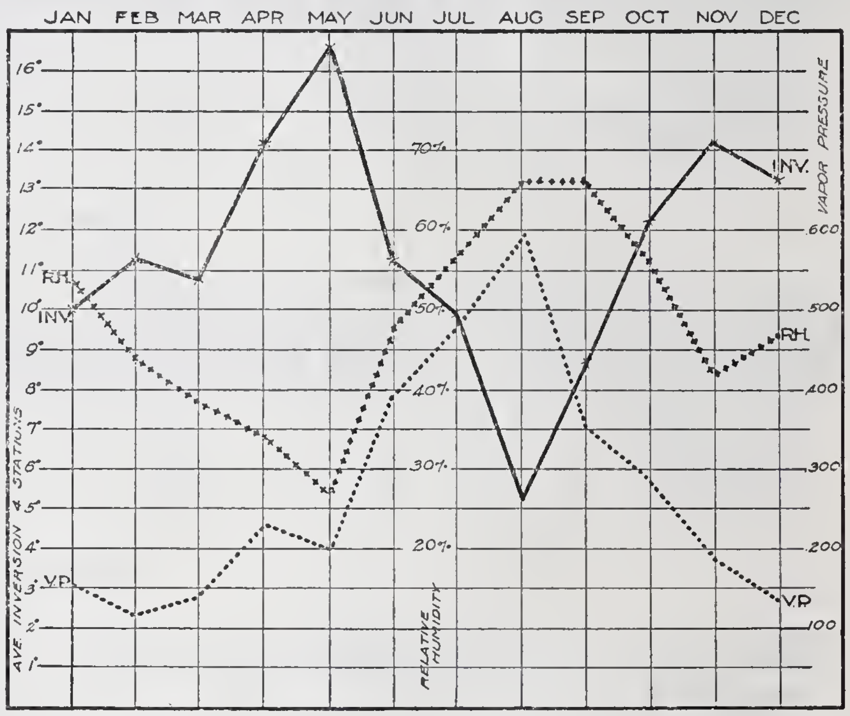

FIG. 53.—Relation of degree of inversion to variation in vapor pressure and relative humidity. R. H.=rel. humidity; V. P=vapor pressure; INV.=inversion.

and a secondary maximum in November at the times of the two minima in relative humidity. The lines in Figure 53 show that this inverse relation is constant, with the exception of a slight variation in the month of March.

There is also apparent, generally speaking, an inverse relation between the range of inversion and the vapor pressure, although the relation is not so close as between the relative humidity and degree of inversion. Vapor pressure is least during the winter months, but the degree of inversion is not greatest at that time, because of the fact that the air is so often disturbed by passing storm areas that it rarely becomes sufficiently warmed to permit convectional exchanges of any marked extent between the free air over the valley and the surface air on the slope and the maximum degree of inversion is found in the spring and autumn months, when long periods of fair weather are prevalent.

The range of inversion is the least during the summer months, and especially during August, when both the relative humidity and the vapor pressure are at their maximum.

The table below presents additional data showing the relation between the vapor pressure and the range of inversion at certain selected stations:

	Low vapor pressure, May, 1913—8 p. m.			High vapor pressure, June, 1914—8 p. m.		
	3	4	5	20	21	22
Vapor pressure (inches)	0.151	0.193	0.286	0.620	0.708	0.664
Inversions (F°):						
Asheville	9	13	13	3	6	5
Hendersonville	15	24	18	5	10	5
Blantyre	14	17	17	5	5	6
Cane River	17	21	21	8	8	8

During the first period selected, May 3, 4, and 5, 1913, the weather was clear and the wind light, with small vapor pressure, and the degrees of inversion were large on the various slopes. In the second selected period, June 20, 21, and 22, 1914, the weather conditions were much the same, except that the vapor pressure was much greater, with small inversions in consequence. During the dry period the inversions ranged from 9° to 24° and during the humid period from 3° to 10°.

Table 17 brings out the variation in inversion on a single slope, Ellijay, during humid and relatively dry periods, respectively. These humid and dry periods consist of seven days each, selected as typical, the vapor pressure at the Asheville Weather Bureau station being employed, the pressure averaging for the humid period 0.572 inches and for the dry period 0.298 inches. It is difficult to secure more than two clear nights in succession in the mountain region with high humidity, and therefore the two periods are made up of seven individual nights each.

The humid period is characterized by a small average diurnal range in temperature, 24.8°, and a correspondingly small inversion at night, 4°, between Nos. 1 and 4. The average diurnal range during the dry period is 40.2°, nearly twice as great as that during the humid period, and the average inversion during the dry period is 18°—over four times that during the humid period.

In the humid period the belt of highest temperature rises more slowly than during the dry period, as shown by the figures in bold-faced type, because of increased absorption of the heat by the air, never reaching a greater height than station No. 4, while during the dry period the belt rises much more rapidly, appearing almost immediately at a high elevation following the setting of the sun, and with decreasing wind velocity, or at least air movement from an unfavorable direction, the belt gradually works itself up to the summit, an elevation of 1,760 feet above the valley floor, and remains there several hours—in this particular case, from 5 a. m. until 10 a. m., after the latter hour the point of highest temperature shifting to No. 1 on the valley floor.

TABLE 17.—*Average hourly temperatures during clear, humid weather and clear, dry weather, selected periods, Ellijay.*

HUMID PERIOD.

	P. M.												A. M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	Noon.
No. 5	75.3	77.7	77.3	77.0	74.7	71.2	67.3	65.6	64.7	64.0	63.7	63.0	62.7	62.2	61.7	61.3	60.8	61.5	63.5	65.0	67.3	69.5	72.0	73.5
No. 4	76.5	78.7	78.5	78.2	76.7	73.0	68.0	67.2	66.5	65.7	65.2	**64.8**	**63.8**	**63.7**	**63.5**	**62.7**	**62.5**	**62.5**	64.0	66.7	68.5	70.5	72.8	74.5
No. 3	78.7	80.7	80.2	79.7	78.7	74.2	71.0	68.3	**67.0**	**65.8**	**65.7**	64.2	**63.8**	63.2	62.3	61.5	61.5	61.5	**64.3**	**67.5**	70.5	72.0	74.7	76.3
No. 2	81.2	82.8	82.0	82.0	80.2	**76.5**	**72.0**	**68.8**	65.8	64.8	63.3	62.5	61.5	61.0	60.5	60.2	59.5	59.8	62.2	66.7	70.3	73.3	76.8	78.5
No. 1	**81.3**	**83.3**	**82.7**	**82.5**	**80.5**	75.8	71.3	66.8	64.2	62.8	61.7	60.7	60.0	59.5	59.2	59.0	58.5	59.3	62.0	66.7	**70.8**	**74.0**	**78.0**	**79.7**

DRY PERIOD.

	P. M.												A. M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	Noon.
No. 5	59.6	60.4	61.4	60.0	55.6	52.4	51.2	50.2	49.4	49.0	48.2	48.2	47.8	47.2	46.6	47.0	**47.2**	**46.8**	**46.8**	**49.0**	**51.2**	**53.8**	**57.6**
No. 4	57.0	59.6	61.6	59.6	57.4	54.6	**52.6**	**51.6**	**51.0**	**50.4**	**49.8**	**49.0**	**48.8**	**48.2**	**48.2**	**47.6**	**47.2**	**46.8**	46.0	46.8	48.4	50.8	53.4
No. 3	61.4	64.0	65.4	64.4	60.2	**56.2**	52.0	49.4	48.0	46.8	45.8	44.6	43.4	43.4	41.8	41.8	40.8	39.8	39.4	40.0	41.8	47.8	55.0
No. 2	61.6	64.4	65.8	**66.4**	**61.8**	55.8	50.0	45.6	43.6	42.2	41.2	40.2	39.2	38.4	37.2	37.0	36.6	36.0	35.4	35.4	37.2	43.6	54.6
No. 1	**65.6**	**67.6**	**68.6**	61.4	56.6	48.6	42.8	39.8	37.8	36.6	35.2	34.2	32.6	32.0	31.0	30.2	29.6	29.0	28.4	30.4	38.0	48.8	**57.6**

NOTE.—Bold-faced figures indicate position of highest temperature on slope at each hour.

As stated previously the greatest inversions invariably occur after a period of clear anticyclonic weather and when a HIGH passes to the east or south of the region. Under the influence of sunshiny days the temperature of the free air at nightfall acquires an initial temperature higher and higher on each succeeding night, thus producing larger and larger inversions, despite the fact that the atmosphere naturally becomes slightly more humid as the period advances. However, the increase in temperature is usually so rapid in proportion to any increase in the absolute humidity that the loss through radiation is apparently not materially affected, but the degree of inversion actually increases until the high pressure over the region gives way to a LOW approaching from the west, with increasing cloudiness, when the inversions either become variable or diminish in degree, depending upon the rapidity of the eastward movement of the LOW. Again, during the closing days of such period the temperature increases slightly as compared with the increase in absolute humidity, and this condition results in a decrease in the loss through radiation and a reduction in the amount of inversion. On this account the last nights of a clear dry period do not show the degree of inversion that may be apparent during the middle of the period, when the change to higher temperature is rapid and the increase in water vapor slow.

The vapor pressure, then, plays a most important part in regulating the extent of inversions. With relatively high pressure and clear weather a small amount of moisture in the air at sundown remaining unchanged, or even increasing slightly, during the greater portion of the night, permits free radiation and loss of heat, as the drier the air the greater the radiation through it. On the other hand, a large amount of water vapor in the atmosphere prevents free radiation, as the heat radiated is largely absorbed by the vapor and does not pass freely through the air. As an inversion is distinctly a radiation phenomenon, it is easily seen that the more rapid the radiation the greater the degree of inversion.

As the degree of moisture in the air is shown by the temperature and the relative humidity, these two factors have to be considered in determining the effect

of absolute humidity on inversions. Aside from other considerations, the higher the temperature and relative humidity the higher the absolute humidity and the smaller the inversion, the lower the temperature and the lower the relative humidity the lower the absolute humidity and the greater the inversion, while between these two extremes may occur combinations of high temperature and low relative humidity, and low temperature and high relative humidity, the absolute humidity being usually relatively higher with the first combination than with the second. As both low temperature and low relative humidity never occur at the same time in the Carolina mountain region, except in the winter when other important factors are at work in producing large inversions, it is only in May with increasing temperature, and in November with decreasing temperature, that we find the most favorable conditions that cause inversions, considering humidity and temperature alone. Moreover, in these two months the other factors which aid in producing inversions—high pressure and clear quiet weather—are usually present in greatest force. Hence inversions have both their greatest frequency and range in May and November, depending upon which month the most favorable combinations occur. However, it is probable that of May and November the largest inversions usually occur in the latter, aside from other considerations, simply because of the greater length of night in which radiation and consequent building up of inversions may take place.

To sum up, nights in which the temperature is moderate or above normal, those occuring in spring and autumn, for instance, with low relative humidity and low absolute humidity, have the largest inversions, while those having relatively high temperature with high relative humidity and high absolute humidity produce little or no inversion; and between these two extremes may occur varying amounts of inversion, depending upon which factor or factors exert a predominating influence.

Blair [5] has found that in early winter with abnormally low surface temperatures the vertical gradients of both temperature and vapor pressure are small as compared with those in early spring and summer and that, in consequence, radiation is less effective in early winter. This may be an additional reason why inversions are not larger on clear calm nights in winter.

Hann [6] states that in the Alps November and December and the first half of January are the most favorable for the occurrence of inversions, because the nights are then the longest, but he probably has in mind the extreme range of individual inversions rather than the average range and the frequency, so far as the winter season is concerned. While large individual inversions are noted in that season in the Carolina mountain region, they are not as large nor is the average as large as in the spring and autumn, and especially in May and November.

Effect of wind direction and velocity upon degree of inversion.—The effect of wind direction and velocity upon inversion is also sometimes considerable. It has already been stated that inversions are of little consequence unless there is a calm or the wind is light in the lower levels, but moderate and even fresh winds often serve to increase the degree of inversion in the upper levels during the Intermediate or Cyclonic Type of inversion. Moreover, when the topographical conditions are such as to produce a mountain breeze down the slope into the valley the temperature rises upon the floor, and the degree of inversion is lessened in consequence.

Again, the wind direction is a factor bearing upon the degree of inversion, even though the breeze be light. When at night the wind blows toward the slope, it brings an increasing supply of warm free air to the upper levels, increasing the degree of inversion, in contrast with the condition when the wind blows away from the slope.

Table 18 presents inversion data for the five slopes at Altapass, Blantyre, Blowing Rock, Tryon, and Wilkesboro for two selected nights, December 5, 1913, and November 4, 1916, the former with moderate northerly and the latter with light southerly winds. The direction of the slope is shown in connection with the numbers of the stations.

On every one of these slopes the inversion is greater when the prevailing wind is blowing toward the slope. The same dates have been selected for all the places, and although on December 5 inversions occurred at Blantyre and Wilkesboro the influence of the northerly winds was sufficient on the southeast slopes at Altapass, Blowing Rock, and Tryon to produce norms instead, where the lowest temperatures were registered at the most elevated points. On that same night an inversion of 11° occurred at No. 2, Wilkesboro, on a northerly slope 150 feet above the base, while Nos. 3 and 4, located on small knobs with relatively free exposures to all winds, were affected but slightly. At Blantyre No. 2, with a northwest exposure, there was an inversion of 10°, while at the highest station, No. 4, located near the summit of the slope, the wind direction is not an important factor, just as at Nos. 3 and 4 at Wilkesboro.

The inversions on the night of November 4, 1916, with southerly winds were quite pronounced on the southeast slopes at Altapass, Blowing Rock, and Tryon, in contrast with the night of December 5, 1913. At the highest level at Wilkesboro, No. 4, on the November date the great inversion noted in Table 18 is not due so much to the effect of the wind in causing a high reading there as to its effect in allowing uninterrupted loss of heat through radiation at No. 1.

The wind direction plays an unusual part in the degree of inversion, as will be further shown in discussing inversion conditions on individual slopes. The direction and velocity have an important bearing upon the development of the mountain breeze down the slope where the surface area above is great and the wind is calm, or at least not blowing from an unfavorable direction. The breeze often develops on a night of inversion, descending the slope and raising the temperature on the valley floor, and thus preventing injury to vegetation. However, unless the surface area above is great this breeze does not develop. Instances of the effect of the mountain breeze on the valley floor at Blowing Rock and Tryon will be later shown by the thermograph traces; also the effect of variation in wind locally at Hendersonville and Mount Airy.

Inversions seldom occur when strong winds prevail from a northerly or westerly quarter, or when the temperature is falling generally along the entire slope, because then norm conditions prevail, and this is also the case when the weather is cloudy.

Table 18 contains the minimum temperatures on two selected nights of inversions, one with northerly and the other with southerly winds, together with the differences between the base station and those higher up on the respective slopes; also the difference in elevation between station No. 1 and those above.

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[5] Blair, Wm. R., Summary of the free air data obtained at Mount Weather. Bulletin, Mount Weather Observatory, 1913, vol. 6.
[6] Handbook of Climatology, by Julius Hann, p. 259. English translation by Ward.

TABLE 18.—*Effect of wind direction and velocity on inversions.*

Principal and slope stations; elevation of base station (feet).	Height of slope station above base (feet).	Northerly winds, Dec. 5, 1913.		Southerly winds, Nov. 4, 1916.	
		Min.	Dif.	Min.	Dif.
Altapass:					
No. 1 (base), elevation, 2,230	......	43	......	32	......
No. 2 (SE.)	250	41	−2	40	+8
No. 3 (SE.)	500	40	−3	39	+7
No. 4 (SE.)	750	38	−5	35	+3
No. 5 (summit)	1,000	37	−6	34	+2
Blantyre:					
No. 1 (base), elevation, 2,090	......	26	......	28	......
No. 2 (NW.)	300	26	0	27	−1
No. 3 (NW.)	450	36	+10	33	+5
No. 4 (NW.)	600	34	+8	39	+11
Blowing Rock:					
No. 1 (base), elevation 3,130	......	39	......	35	......
No. 2 (S.)	450	39	0	45	+10
No. 3 (base), elevation 3,580	......	39	......	28	......
No. 4 (SE.)	625	39	0	40	+12
No. 5 (SE.)	800	37	−2	39	+11
Tryon:					
No. 1 (base), elevation 950	......	51	......	39	......
No. 2 (SE.)	380	49	−2	46	+7
No. 3 (SE.)	570	47	−4	47	+8
No. 4 (SE.)	1,100	42	−9	45	+6
Wilkesboro:					
No. 1 (base), elevation 1,240	......	36	......	29	......
No. 2 (N.)	150	47	+11	33	+4
No. 3 (N.)	350	48	+12	40	+11
No. 4 (W.)	430	48	+12	46	+17

Effect of variation of soil cover upon degree of inversion.—In connection with the various seasons density of vegetation also is effective in lowering the night temperature and increasing the degree of inversion. Radiation from vegetation is most free, almost as great as from an ideal black body, and where the vegetation is dense on the valley floor and the summit practically free from growth the effect is considerable. This is especially noticeable during the period of growth. While the maximum degree of vegetation is not reached in the Carolina mountain region during May, except at the lower levels, nevertheless vegetation has apparently some effect at that time upon the degree of inversion. By November the vegetation has changed considerably, but the influence then of the longer nights predominates. In the winter season there is usually no difference in the vegetal cover along an entire slope from summit to base, but there is likely to be more snow in the higher levels, and because of great loss of heat through radiation from a snow-covered surface inversions may not be as large then on that account, aside from other considerations already stated.

Inversions on individual slopes as affected by topography.—Having now brought out the distinguishing features of inversions as affected by weather conditions and soil covering, it seems necessary to present additional data for selected individual slopes. Reference will here be made to certain tables and illustrations in order to indicate the influence of topography in all its phases on the phenomenon of inversion. In this discussion of individual groups some of the statements made in preceding pages will, necessarily, be repeated so as to cover fully the various situations; but this can hardly be avoided.

Altapass and Ellijay.—Judging from the figures found in Tables 2 and 2a, containing minimum temperature and inversion data, one would conclude that inversions of considerable amount seldom occur on the Altapass slope, but this is only because No. 1 is not a proper base station for comparison with those higher up, as it is located far above the valley floor. In order to establish definitely the fact that on this slope inversions do occur which compare favorably with those on other slopes, a place called North Cove, about 2 miles down the slope and 730 feet in vertical distance below No. 1, may be designated as an imaginary base station and, for convenience, be termed station No. 1a. It is fairly representative of valley-floor conditions and can properly be considered the base of the Altapass slope. In elevation No. 1a is about 1,730 feet below No. 5, located on the ridge, the vertical distance between the two points being only 30 feet less than that between the base and summit stations at Ellijay, the longest slope employed in the research, 1,760 feet. The elevation above sea level of No.1a in North Cove is 1,500 feet, about equal to that of the base station at Gorge, only 15 miles distant, the average minimum temperatures of which during inversion periods are doubtless approximately the same as those at North Cove.

The table following embraces data for Altapass and Ellijay for the May and November selected periods of inversion shown in Table 2a, but, in addition, No. 1a appears as the base station for Altapass, with readings estimated from the records of the Gorge base station and estimated readings for the May period for station No. 5 at Ellijay, the latter not having been in operation in 1913.

Stations and description.	May 1–6, 1913.		Nov. 2–5, 1916.	
	Average.	Difference.	Average.	Difference.
Altapass:				
No. 1a base station 1,500 feet above sea level	42.0	....	31.2	....
No. 1, southeast, 730 feet above base	50.3	+8.3	39.8	+8.6
No. 2, southeast, 980 feet above base	55.2	+13.2	42.5	+11.3
No. 3, southeast, 1,230 feet above base	53.3	+11.3	40.8	+9.6
No. 4, southeast, 1,480 feet above base	51.3	+9.3	39.5	+8.3
No. 5, summit, 1,730 feet above base	49.7	+7.7	39.5	+8.3
Ellijay:				
No. 1, base station 2,240 feet above sea level	41.5	....	30.0	....
No. 2, north, 310 feet above base	49.0	+7.5	34.0	+4.0
No. 3, north, 620 feet above base	53.3	+11.8	39.0	+9.0
No. 4, north, 1,240 feet above base	58.5	+17.0	46.5	+16.5
No. 5, summit, 1,760 feet above base	58.0	+16.5	45.0	+15.0

Readings at No. 1a Altapass, May and November periods, and at No. 5, Ellijay, May period, estimated.

With the use of these figures it is apparent that station No. 1 at Altapass, up to the present considered as the base station, averages considerably higher than No. 1a during periods of inversion. In May the excess at No. 1 is 8.3° and in November 8.6°. The center of the thermal belt is shown here to be near station No. 2, with excesses in both periods of 11° to 13°. From No. 2 upward to the summit the temperature gradually decreases during inversion weather, although in the November period the summit station, 1,730 feet above the base, has as high an average minimum as station No. 4, 250 feet below. While station No. 5 at the summit averages higher than No. 1a, it is rarely the warmest on the entire slope and only on especially favorable nights and at individual hours, rather than through the entire night.

The middle of the thermal belt at Altapass usually lies between Nos. 2 and 3, whether we consider No. 1 or No. 1a as a base, the latter being used merely to show that large inversions do occur on this slope.

At Ellijay, as shown by the table, there is an increase in temperature more or less regular from base to station No. 4, 1,240 feet above the valley floor, and this point marks the usual position of the center of the thermal belt on that slope, although sometimes, under favorable conditions, the center reaches to the very summit.

Above Altapass No. 3 the minimum temperature is usually lower during nights of inversion, both because of the increase in elevation and because of the increasing area of radiating surface, the cool air overlying the plateau above being in close proximity. The summit area along the main ridge, where station No. 5 is located, is unusually great, no other summit station having similar

environment, and with the possible exception of Tryon there is no other slope so affected during nights of inversion. However, comparative figures can not be given for Tryon, as the highest station employed there during the period of the research was considerably below the summit. Figures 26 and 21—contour maps of Altapass and Tryon, respectively—bring out this situation as regards summit area. The loss of heat from this great area along the ridge is rapid in the clear weather usually favorable for inversions and almost always sufficient to prevent the center of the thermal belt from reaching the summit, and generally its influence is sufficient to keep the center of the belt down to the level of Nos. 2 and 3 at Altapass, just as at Tryon, even though the temperature at the summit is often higher than at the base. The situation at the Ellijay summit is much like that on the isolated peaks at Cane River and Gorge, where the center of the thermal belt is usually close to the summit. It is only when the winds are southerly that the center of the thermal belt at Altapass is at the level of the summit, as then the warm free air flows on to the slopes.

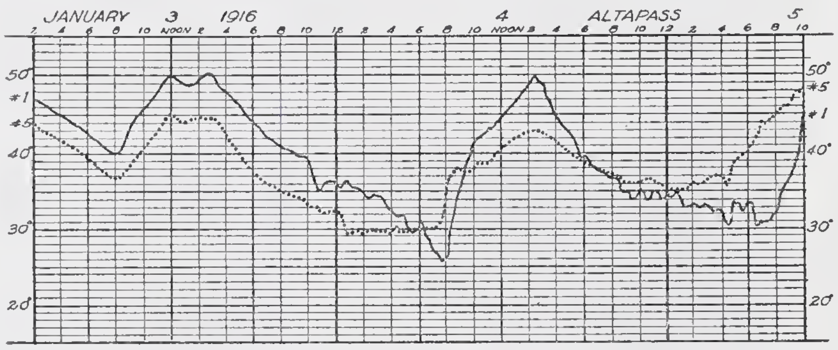

Fig. 54.—Thermograph traces, January 3–5, 1916, stations Nos. 1 and 5, Altapass, showing importation of warm air at summit.

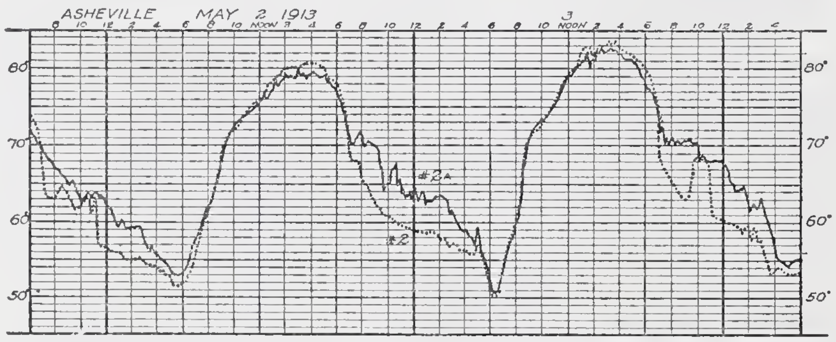

Fig. 55.—Thermograph traces, May 2–3, 1913, north and south facing slopes, Asheville.

Figure 54 shows a norm condition at Altapass during most of the night of January 3–4, 1916, followed by a quick recovery, while on the following night, the 5th, under the influence of a rapidly approaching LOW, an inversion of the Cyclonic Type occurred, the thermograph at No. 5 beginning to rise as early as 1 a. m., while that at No. 1 fell slightly. At 7 a. m. on the 5th the temperature at No. 5, the summit, was the highest on the slope, exceeding the reading at that hour at No. 1 by 13°. Under the discussion of inversions at Cane River other similar marked examples of rises in temperature will be explained.

Asheville.—It has been shown that the highest minima during inversion weather, without exception, are found at the most elevated stations on each of these two facing slopes, No. 3 and No. 3a, and that the stations on the south slope nearly always average higher than those on the opposite northerly slope, there being a greater difference in minima between Nos. 2 and 2a than between Nos. 3 and 3a, because of a correspondingly greater difference in inclination of slope at the two former stations than at those higher up, as explained under the discussion of "Average minimum temperatures." Figure 55 shows the differences in temperature prevailing between Nos. 2 and 2a on a clear quiet night. No. 2 is located on a slight grade where the cold air sometimes accumulates, while No. 2a is situated on a steep slope and has better opportunity for exchange with the warm free air. Moreover, the southerly slope being heated more during days of sunshine than the northerly slope naturally should have somewhat higher ensuing minima. This graph also contains examples of sudden rises in night temperature due to the mechanical heating of cold air brought down from the slope above, as described in detail on previous pages. Asheville No. 2 is ideally situated to show such irregularities in temperature on clear quiet nights.

Blantyre.—In Figure 56 are shown thermograph traces at the four Blantyre stations during a typical inversion period, November 12–14, 1913. The peculiar location of No. 2, so far as radiation is concerned, is well illustrated by the frequently large fluctuations in temperature on

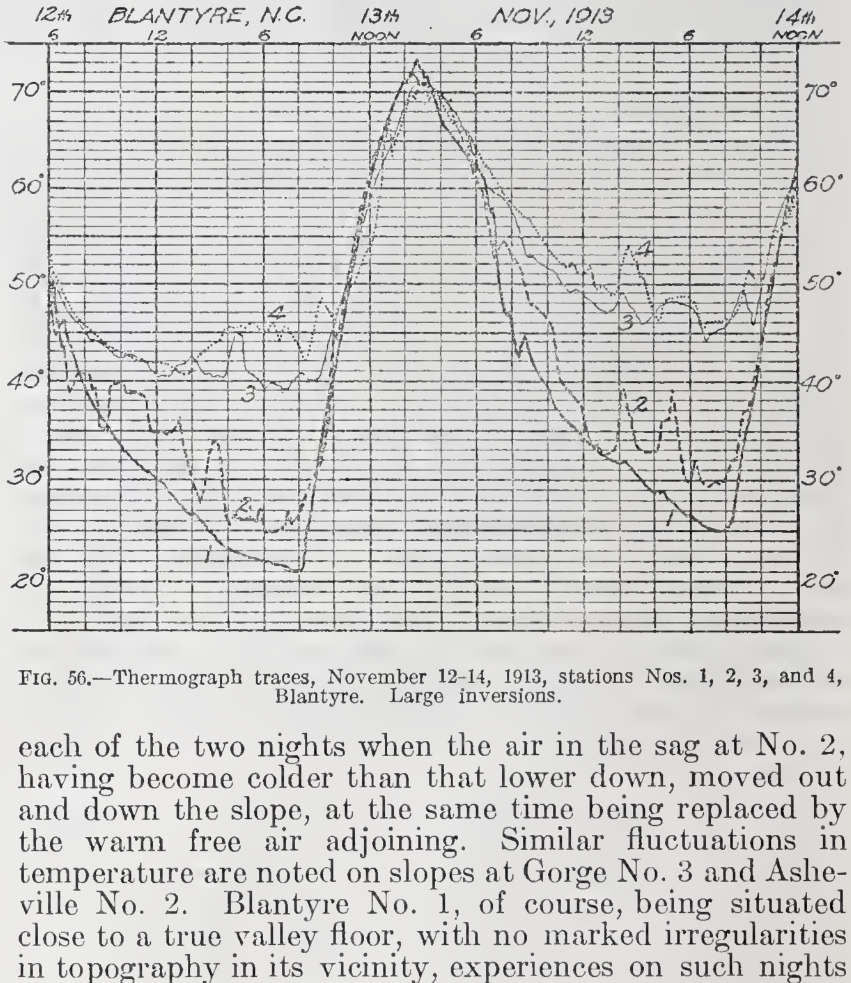

Fig. 56.—Thermograph traces, November 12–14, 1913, stations Nos. 1, 2, 3, and 4, Blantyre. Large inversions.

each of the two nights when the air in the sag at No. 2, having become colder than that lower down, moved out and down the slope, at the same time being replaced by the warm free air adjoining. Similar fluctuations in temperature are noted on slopes at Gorge No. 3 and Asheville No. 2. Blantyre No. 1, of course, being situated close to a true valley floor, with no marked irregularities in topography in its vicinity, experiences on such nights a steady decline in temperature under continuous and uninterrupted radiation, as illustrated in Figure 56. Although the grass around Blantyre No. 1 has been kept rather short, the bottom lands generally are covered with a dense growth of vegetation, which favors rapid loss of heat on clear quiet nights, and as the slope of the valley is very slight at that point the area may be likened to a vast frost pocket during nights of inversion with especially low minima.

The curves of temperature at the two stations on the slope, Nos. 3 and 4, shown in Figure 56, resemble each other much more closely than those at the two lower stations. This graph also shows the largest inversion at any hour noted at Blantyre during the research, 27°, between Nos. 1 and 4 at 8 a. m. on November 14. On the 13th a difference of 26° was recorded between the

summit and base stations. During the same period unusually large inversions were observed generally over the mountain region, that at Gorge, 31° at 6 a. m. on the 13th, being the greatest at any location during the four years of record. This graph also shows the extremely large range in temperature common to valley floor stations under favorable conditions, in this particular instance the temperature at No. 1 rising from a minimum of 21° to a maximum of 73° on the 13th.

The middle of the thermal belt at Blantyre would almost always lie considerably above the level of the summit of Little Fodderstack were the slope higher, judging from a comparison of temperatures with No. 3a at Asheville, the latter, with an elevation 150 feet higher, always having higher minimum readings.

Blowing Rock and Highlands.—The effect of wind direction and velocity is well shown in Figure 57, which contains copies of the thermograph sheets at stations winds, but as soon as the wind velocity decreases, as shown by the hours of 10 p. m. and midnight, No. 3 fell below the readings at station No. 5, because loss of heat through radiation was then allowed to continue without being offset by turbulence. With a slight increase in velocity after midnight, note the rise in temperature at No. 3, and with a further decrease to calm during the hours from 4 to 8 in the morning of the 2d, note the fall at No. 3. The night of the 2d–3d shows the effect of a light mountain breeze in that the temperature at No. 3 is prevented from falling to a low point, partly because the air in descending the slopes of the Flat Top orchard is slightly warmed by compression. By 2 a. m. on the 3d the temperature at No. 3 is higher than at No. 5 and continues so until sunrise. Thus a condition resembling a "top freeze" is formed. Shortly after sunset on the 4th the wind changed to southerly, increasing at first, but later gradually di-

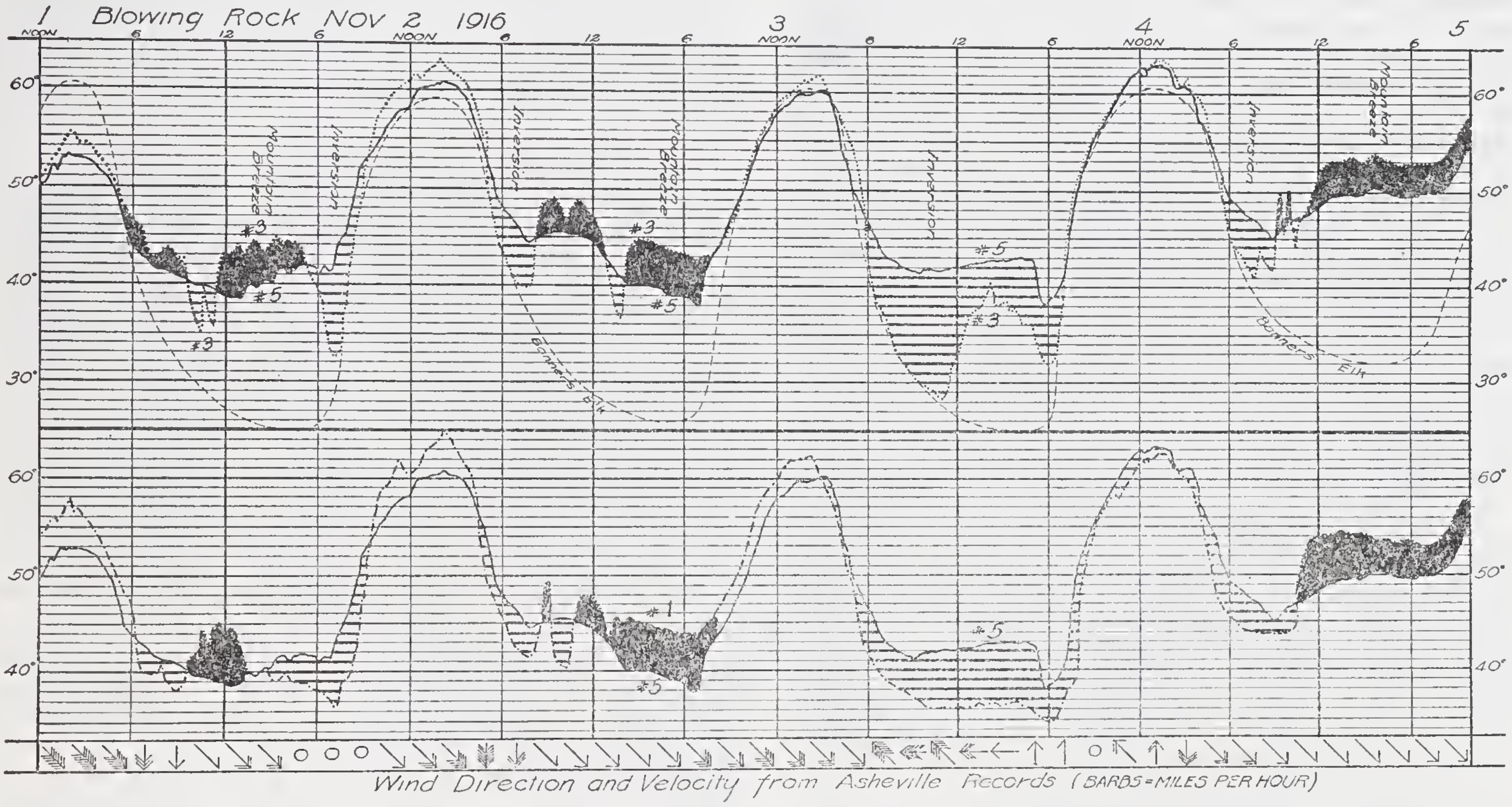

Fig. 57.—Thermograph traces, November 1–5, 1916, stations Nos. 1, 2, 3, and 5, Blowing Rock; also wind direction and velocity at Asheville.

Nos. 1, 3, and 5 at Blowing Rock for the period from November 1 to 5, 1916, together with hourly wind directions and velocities taken from the records of the Weather Bureau office at Asheville for the same period. The light broken line is a trace constructed for comparative purposes from daily extremes recorded at Banners Elk, N. C., at practically the same elevation, but a few miles distant from the edge of the plateau. The weather during this period was clear and dry. In the upper portion of the graph a comparison is shown between Nos. 3 and 5, located in the Flat Top orchard, and it will be seen how quickly the temperature changes, especially during the night, in response to a change in direction and velocity of wind, even though the change in the latter be small. The lower part of the graph compares No. 1, located in the China orchard, with No. 5, in the Flat Top orchard.

During the early evening of the 1st the temperature in the Flat Top orchard (upper portion of graph) is kept fairly uniform by the light to moderate northwest minishing until it reached a calm about 9 a. m. This light southerly wind brought large amounts of warm free air to the slope at the elevation of No. 5, while No. 3 at the foot of the slope is not affected, loss of heat continuing there unimpeded during the night, except from 11 p. m. to 2 a. m., when the wind changed to easterly and a slight rise in temperature occurred. With a change in direction again to south, the temperature fell. This night of the 3d–4th is an excellent example of large inversions in both orchards, as shortly after 10 p. m. the temperature at No. 4 was about 16° higher than No. 3 for a difference in elevation of 175 feet, and No. 2 in the China orchard at the same hour was about 10° higher than No. 1 for a difference in elevation of 450 feet.

The same response to change in wind direction and velocity can be followed in the thermograph traces in the lower portion of the graph, only the effects are not so marked in the China orchard because of difference in topography. Thus we see how important in determining the extent of inversion at Blowing Rock is this factor of

wind, and the effect does not necessarily appear in average conditions or even in the daily minimum temperatures, because during portions of the same night entirely different conditions may prevail. On the night of the 1st–2d, the minimum at No. 3 was about 33° at 7:30 a. m., the lowest reached at any station during the night, yet shortly after midnight the temperature at No. 3 was over 6° higher than at No. 5, which at that time was the lowest in the orchard.

This influence of the mountain breeze at Blowing Rock No. 3 is the main reason why the temperature there on some nights is so much higher than at Highlands No. 3 and also why the number of large inversions in the Flat Top orchard, at the base of which No. 3 is located, is so much smaller than the number in the Waldheim orchard at Highlands (see Tables 14 and 16). Both No. 3 stations at Highlands and Blowing Rock have about the same elevation, with annual mean temperatures for the period of observations differing by only 0.3° (see Table 4). The surface area in the vicinity of the higher levels of the Blowing Rock orchard station No. 5 is considerable, being almost flush with the plateau on which the air is rapidly chilled through radiation on clear nights, and in flowing down the slopes of the orchard it finds an outlet below No. 3, so that this descending current, being warmed mechanically, often prevents the temperature at No. 3 from falling to as low a point as it otherwise would. In the China orchard this descending air doubtless passes over No. 1 at a considerable elevation and ordinarily does not affect the temperature at that station, which is located on a rather steep slope, much unlike No. 3 in the Flat Top orchard. Highlands No. 3 has no such mountain breeze, as it is located in a small saucer-shaped depression with no outlet below a slope culminating in a knob. A slope on one side and timber on the other sides completely surround this small pocket.

Cane River.—The slope at Cane River is rather steep and culminates in two isolated peaks or knobs, with generally sharp profile and small mass in proportion to elevation, rising considerably above the surrounding country within a radius of several miles. All these factors, with their resulting reduction of radiating surface near the summit and the better exposure to the great mass of free air which faces the higher stations, cause the temperature at No. 4, located on one of the knobs, to approach that of the free air on nights with lights winds.

This effect of the free air temperature at No. 4 is more marked than at any other individual station in the research. In fact, during January, 1915, it was so marked as to show in the hourly values when the average temperature at No. 4 gradually and continuously rose after midnight, the minimum occurring the previous evening. These rises in temperature at summit stations constitute one of the most interesting features of the research, and time will be taken now to go into the reasons for them and also to show some traces illustrating the conditions at Cane River. The influence of the free air temperature in determining the minimum at No. 4 is felt under two different types of inversion, the Intermediate and the Cyclonic. In both cases there occurs a gradual rise in temperature at the top station, while the temperature lower down continues to fall from continued radiation where the freedom of air movement is restricted. Again, as stated before, clear weather with light wind is usually associated with the Intermediate Type and increasing cloudiness and wind with the Cyclonic Type.

Under the influence of a combination of these two conditions there occurred at Cane River on January 27–29, 1914, the most remarkable example of rising temperature at a summit station noted in the research, with clear weather and high pressure centered somewhat to the east of the mountain region and a deep LOW approaching from the west with a tendency toward light to moderate southerly winds, though probably not enough to disturb the calms in the coves and valley floors. Figure 58 shows the thermograph traces during this period at Nos. 1 and 4. From 7 p. m. of the 27th the temperature at No. 4 rose from 46° to 57° at sunrise of the 28th, while the temperature at No. 1 fell continuously from a reading of 54° at 4.00 p. m. on the 27th to a minimum of 27° at sunrise the 28th, thus producing an inversion of 30°, the largest noted at Cane River. On the night of the 28–29th there occurred an inversion of the Ideal Type, when the temperature fell gradually at both top and base stations during the night, although the fall at No. 4 was retarded and did not reach a low point. On this date there was an inversion of 24° at 8 a. m.

Another example of this rise in temperature at the summit station at Cane River, which is entirely due to the bringing in of warmer currents of air and may be considered a purely Cyclonic Type of inversion, occurred during the period December 19–23, 1916, shown in

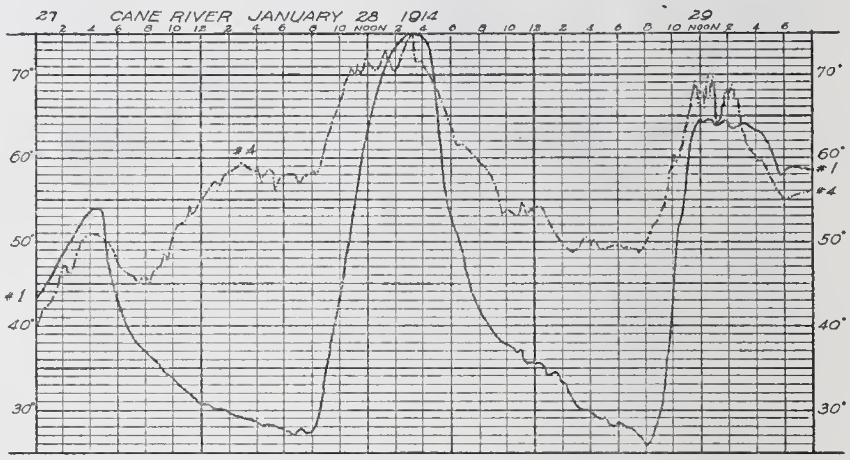

FIG. 58.—Thermograph traces, January 27–29, 1914, stations Nos. 1 and 4, Cane River. Large inversions.

Figure 59. Beginning with 10 p. m. on the night of the 19th, the temperature rose continuously at No. 4 from a minimum of 18° to a maximum of 51° at 11 a. m. on the 21st, or during an interval of 37 hours, without regard to the usual diurnal changes which took place at No. 1, 1,100 feet below. During the period from 8 a. m. of the 19th to 8 a. m. of the 20th a deep LOW moved rapidly southeastward from the middle Rocky Mountain to the lower Mississippi Valley, and by the morning of the 21st a trough-like depression covered the Atlantic coast States with the LOW centered south of Alabama. This condition caused moderate and fresh southeast winds for a 48-hour period at Cane River. By the morning of the 22d the disturbance had increased greatly in intensity and was located over the middle Atlantic coast, with strong northwest winds over the mountain region, resulting in a norm condition, as shown by the trace. The rise in temperature at No. 4 during the night of the 22d-23d at the same time when there was a gradual fall at No. 1 is a good example of the Intermediate Type of inversion.

Still another example of the Intermediate Type of inversion at Cane River is found on the night of January 3–4, 1916, illustrated in Figure 44, a difference of 21° between Nos. 1 and 4 being observed at 8 a. m. on the 4th, the temperature rising steadily at the summit station and falling at the base from about 7 p. m. of the preceding day. On the following night, owing to the rapid approach of a LOW, an inversion of the Cyclonic

Type occurred, and this condition is shown at Altapass on the same night in Figure 54.

Gorge and Globe.—The slope at Gorge is quite unlike any of the other slopes, the grade being slight and the slope long. Like Cane River, the highest temperatures in inversions are invariably found at the summit, as after No. 2 on each slope is reached, the amount of free air in proportion to the surface area continually becomes greater and the minima higher and higher. Because the elevation of No. 5 at Gorge is relatively low, the temperature of the free air opposite it is still high enough to retard the fall in temperature there, so that the summit station shows a higher reading than at lower elevations.

As station No. 2 partakes more of the nature of a valley floor station because of the large amount of radiating surface in the shape of surrounding hills, which rise to an elevation as high as and even higher than No. 2, and because of the comparatively flat cove-like location, we find almost as low readings here as at No. 1, as stated previously. Consequently marked inversions at Gorge are not apparent until after No. 2 is passed, the low opposing slopes cutting off any supply of warm free air. However, the inversions in the higher levels at Gorge are the largest found on any long slope, and this is because No. 1 is relatively cold for its elevation and the summit station No. 5 is on a knob, where the mass is small and where it faces an almost unlimited volume of free air the temperature of which is comparatively high on account of the low elevation of the slope above sea level.

A most remarkable instance of large inversions, the greatest in the entire four-year period, to which reference has been made before, occurred at 6 a. m. on November 13, 1913, at Gorge, when a difference of 31° was noted between Nos. 1 and 5, the temperature rising at No. 5 and simultaneously falling at No. 1 (see fig. 75). This condition was brought about by a combination of the Cyclonic and Intermediate Types of inversions.

As Globe and Gorge are only about 15 miles apart, with base stations within 200 feet of the same elevation above sea level, it is interesting to note the variation in minimum temperature during nights of inversion on these two slopes as affected by local topography. The average minima at the base station at Gorge are consistently lower than those at Globe during all inversion periods, notwithstanding the fact that Gorge No. 1 is over 200 feet lower in altitude, and this is because of the difference in local exposure. Again, the readings at No. 2 Gorge are always lower than Globe No. 2 because of the great difference in the surroundings, the former station being located in a cove and surrounded by a large number of radiating surfaces in the shape of hills, while Globe No. 2 faces a sufficiently large volume of warm free air to prevent the temperature from reaching a low point on inversion nights.

The differences between the summit stations are small, although in this comparison the summit station at Gorge averages the higher because of the freer exposure on the actual summit with small mass, while Globe No. 3 is on the summit of a descending spur of Grandfather Mountain, which reaches northwestward beyond and above for several miles, with increasing mass or surface area.

Hendersonville.—The most prominent feature concerning the inversions in this group is the effect of wind direction and velocity as modified by local topography, and this is shown strongly by the average minimum temperatures for the selected May period of inversion (Table 2a), when with calm nights or with light southerly winds there is an average difference of 9.5° between Nos. 2 and 3, the latter station being the higher. Occasionally the highest temperature is found at No. 2, and this is solely because of the effect of northerly winds. The middle of the thermal belt is usually found at No. 4 and sometimes may even be above that station, at the level of the summit of Jump Off Mountain, located to the southwest and nearly 200 feet higher.

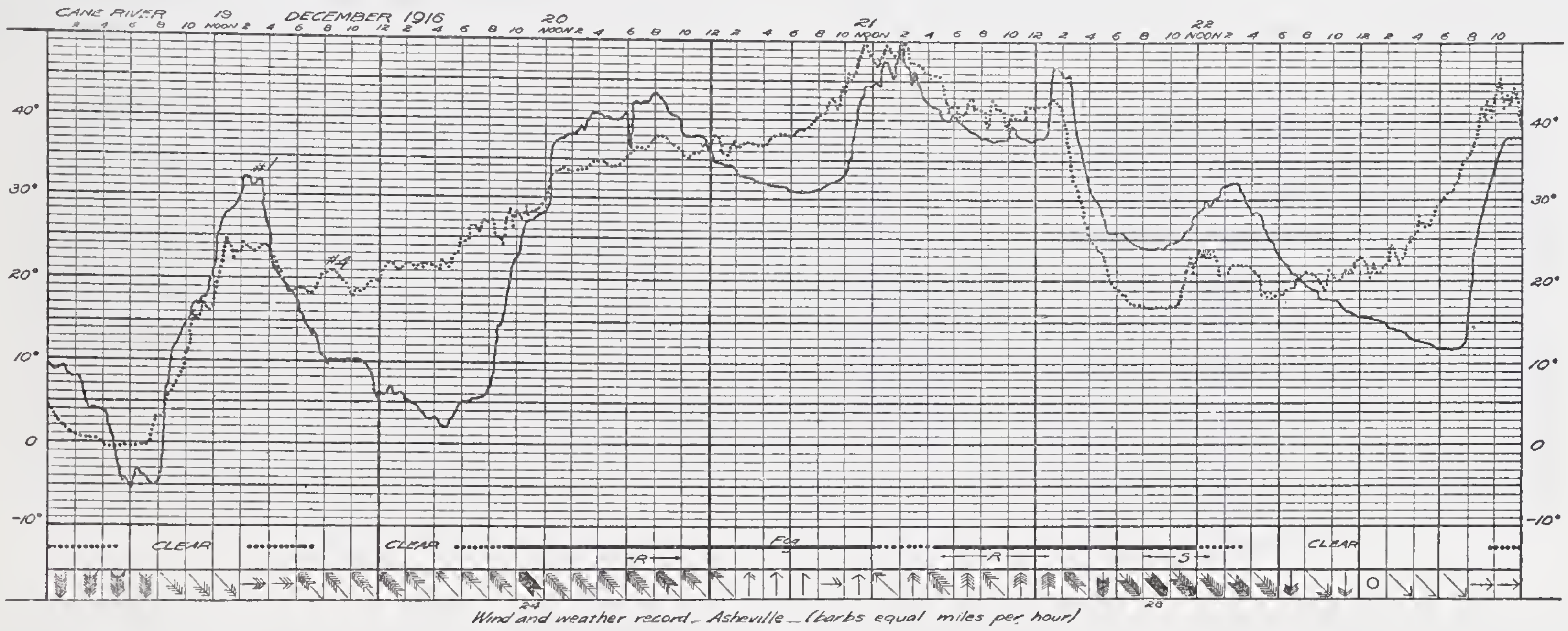

Fig. 59.—Thermograph traces, December 19–23, 1916, stations Nos. 1 and 4, Cane River.

This influence of wind direction and velocity during the November period is brought out in the discussion of Table 2a, but it does not show strongly in the averages, because on some of the nights the effect was only felt during a portion of the night. In order to show graphically this influence, figure 60 has been prepared showing the superimposed thermograph traces for two selected periods in November, 2d to 5th and 19th to 21st, inclusive, for Nos. 1, 2, and 4, to which has been appended the hourly wind direction and velocity, as recorded at the Asheville Weather Bureau station.

Figure 60 illustrates the variation in temperature between a base and summit station during a cold night through a subsequent warm and rainy period to another cold night and shows typical inversions as well as the rapid recovery in temperature aloft. Note the continuous rise in temperature at the summit station, No. 4, from 10 p. m., November 19, to 11 a. m., November 21, coincident with falling temperature at the base station, No. 1, during the nights on these two dates.

It will be recalled that Hendersonville No. 2 is in a cove, with the air movement from southerly and easterly quarters much retarded by the partially inclosing forest areas and the small ridge sheltering this cove. The stagnation of the air movement on nights when winds from these directions blow results in uninterrupted radiation throughout the night with consequent low minima, while the better exposure of No. 2 with reference to northerly winds tends to promote mixture of the chilled air in the cove with the warm free air. The same effect results when the air movement is very light, regardless of the direction of wind. Thus on the night of the 1st–2d, with a light northwest wind, we find the temperature at No. 2 as high or higher than No. 4 at the summit and from 10° to 15° higher than at No. 1. On the following night, during intervals of light northwest wind and calm or variable wind, the temperature at No. 2 fell and recovered frequently, but with an increased wind velocity from the northwest shortly before sunrise the temperature rose slightly and equaled that at No. 4. During the evening of the 3d a moderate southeast wind prevailed, but did not prevent a strong inversion between Nos. 1 and 4. However, at No. 2 we find a remarkable lowering of the temperature, for a time keeping pace with No. 1, 450 feet lower. The depression of the temperature at No. 2 as compared to No. 1 was greatest about 8 p. m. with a 10-mile-an-hour wind from the southeast. Toward morning, with lessening wind velocity, some exchange with the warm free air was permitted, and a slight excess in temperature is noted over station No. 1, though not enough to prevent a heavy or killing frost at No. 2. Meanwhile the temperature at No. 4 remained close to 50°, with an average inversion of over 20° between Nos. 4 and 1. Again, on the following night, 4th–5th, a light northwest wind followed by a calm near midnight resulted in lowering the temperature at No. 2, although a recovery was again noted with increase of wind before daylight.

The influence of wind direction and velocity upon the temperatures at Hendersonville Nos. 2 and 4 is also well shown by the thermograph traces during the period November 19–21, 1913, inclusive, especially during the night of the 20th–21st, when an inversion of 28° is noted between Nos. 1 and 4, the greatest observed at Hendersonville during the period of the research.

Figure 60 illustrates the effect of wind direction and velocity on temperature, especially noticeable at station No. 2. Shaded portions of graph indicate the temperature excess, in both time and amount, at station No. 4 over that at No. 2.

Mount Airy—The inversions at Mount Airy are not large, taking the year as a whole, and the largest amounts by far are found in the unusually favorable period during May. On one night during the selected May period (Table 2a) of inversion there was a difference of 16° between Nos. 1 and 2, equivalent to an increase of 1° in temperature for each 10 feet in altitude. It is quite probable that these large inversions in May represent the maximum differences that are possible on that slope. Because of the small elevation of this group of stations and the slight difference in elevation between the summit and the base stations, the belt of highest temperature on the west slope is sometimes at No. 2 and sometimes reaches the summit, No. 4; and on the east slope, a similar situation prevails. When the wind is from a westerly direction the highest temperature is found at No. 2 instead of at the summit, because large quantities of warm free air at a low elevation are then brought to this westerly slope. With all other conditions, the highest temperatures are normally found at the summit.

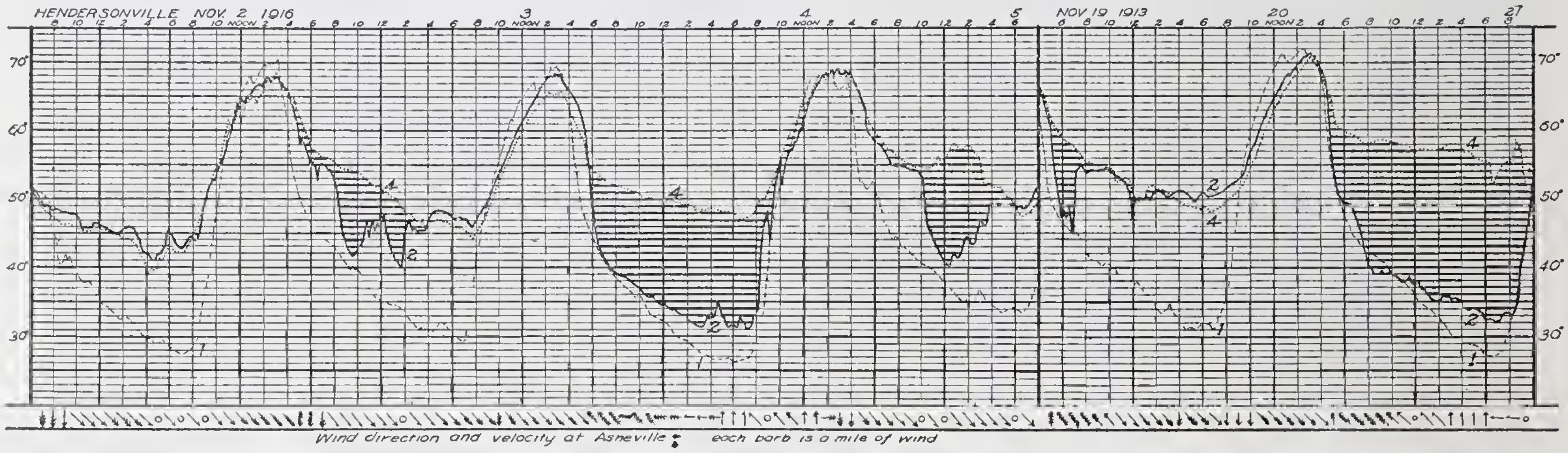

Fig. 60.—Thermograph traces, November 2–4, 1916, and November 19–21, 1913, stations Nos. 1, 2, and 4, Hendersonville.

The effect of inclination and direction of slope is shown by the minima at Nos. 2 and 3, the former being located on a steep westerly slope and the latter on a more gentle easterly slope, both stations having the same elevation above No. 1.

Figure 61 shows the differences in temperature which prevail on clear quiet nights when, as a result of the different topographical features, the minimum at No. 2 may be nearly 10° higher than at No. 3.

Tryon.—Because of the peculiar topographical features at Tryon (fig. 21), which affect the flow of air, there are some remarkable variations in the extent and amount of inversions during the course of a year. Normally, as shown by Table 2a, the middle of the thermal belt lies between Nos. 2 and 3, at an elevation of only 400 feet above the valley floor. The highest minima are usually found at No. 2. On no other slope is the center of the thermal belt found so close to the valley floor.

The controlling factor at Tryon in affecting inversions, both in amount and extent, is the mountain breeze, which is greatly aided in its development by air movement from the west down the Pacolet valley. In fact, this breeze is a most vital factor in governing the minima

at No. 1, and time will be taken to discuss the subject in detail. Before the beginning of the mountain breeze at

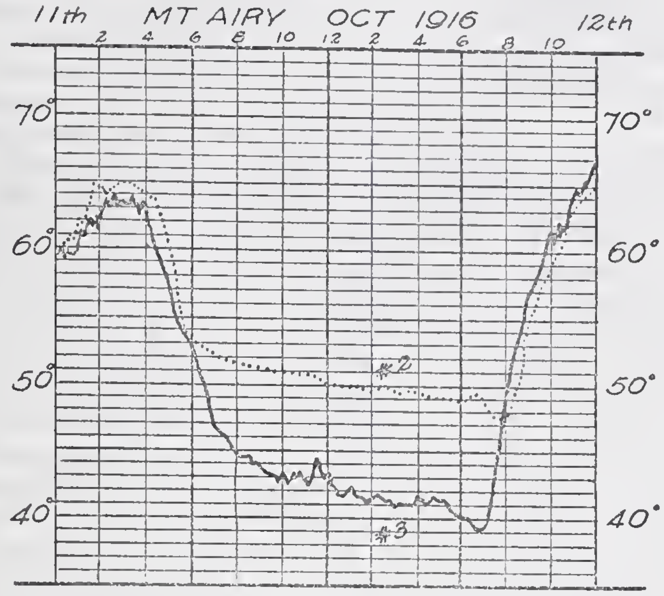

FIG. 61.—Thermograph traces, October 11–12, 1916, stations Nos. 2 and 3, Mount Airy. Variation in minimum temperature due to inclination of slope.

night there is an inversion along the sides of the gorge of the Pacolet River and the inclosing Blue Ridge, while on the Saluda plateau above radiation lowers the temperature so rapidly that there is a cold blanket of air in contact with the warmer air on the slopes. As this unstable condition can not last long, the cold air nearest the slopes finally breaks through the warm air on the slopes and forces the cold air out of the valley bottom, at the same time warming itself by compression. This often prevents low temperatures at No. 1. Now when the air movement over the Saluda plateau has a westerly component, as during anticyclonic weather, the continual displacement of the chilled surface air on the plateau to a position over the warm air on the sides of the gorge gives a constant impetus to the movement of the mountain breeze, and under such conditions the temperature remains high at No. 1 during the entire night, while in other valleys at the same elevation and under the same weather conditions, but uninfluenced by a breeze, the temperature may be from 10° to 20° lower. This accounts for the fact that inversions may occur on other slopes when conditions approaching a norm are noted at Tryon. Thus we find the average minima at Tryon No. 1 during the November period (Table 2a) when the breeze was quite marked, much higher than observed at all other typical valley-floor stations, such as Gorge, Blantyre, and Bryson, while during the selected May period (Table 2a), when the influence of the mountain breeze at Tryon was unimportant in affecting the minima, the differences between the Tryon base station and those at Gorge, Blantyre, and Bryson are much less.

Again, we note that at Tryon the summit station, No. 4, averages considerably higher as compared with the base, No. 1, in periods of inversion unfavorable for a breeze down the slope, such as the May period, than in periods when the breeze prevails at night.

On nights unfavorable for the mountain breeze during inversion weather, the difference in temperature between Nos. 1 and 2 or between Nos. 1 and 3 may equal or exceed any inversion in the region. For instance, during the May period (Table 2a) the largest individual inversion at Tryon is 20° between Nos. 1 and 2, differing in elevation by 380 feet, while the largest inversion on any one night during this period between Nos. 1 and 5 at Gorge, these stations differing in elevation by 1,040 feet, is but 4° more. On February 18, 1916, the inversion at Tryon was 23°, which was 3° in excess of any other inversion in the region the same night.

Figure 62 contains the thermograph traces at Tryon for stations Nos. 1, 2, and 4 from noon, October 27, to noon, October 31, 1914. This period is one of the most remarkable found at Tryon, as the effects of air movement combined with the peculiar topographical features are excellently illustrated by the thermograph sheets for the nights of the period mentioned above; in fact, during the three nights beginning with that of the 28th–29th, the effect upon the temperatures at Nos. 1, 2, and 4 of light easterly winds, moderate westerly winds, and light westerly winds are successively shown, and the vertical temperature gradients on the Tryon slope at midnight of these three nights are illustrated by curves in Figure 64, the adiabatic gradient being represented by the straight line at the left. These two graphs are discussed in the following paragraphs.

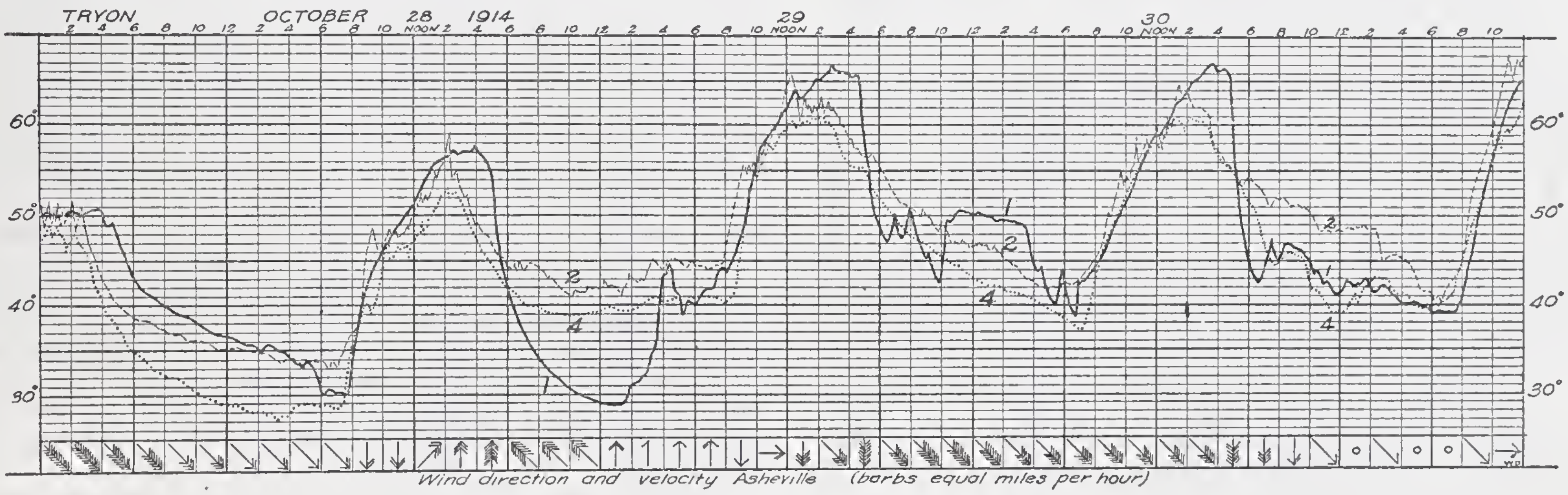

FIG. 62.—Thermograph traces, October 28–31, 1914, stations Nos. 1, 2, and 4, Tryon.

The weather was clear each night of this selected October period at Tryon (fig. 62), and during the greater portion of the night of the 27th–28th, under the influence of diminishing northwest winds, the temperature at No. 4 was the lowest on the slope. So long as there was any force at all to the wind, the temperature at No. 1 was prevented from falling to a low point, but as soon as the wind diminished the temperature on the valley floor became almost as low as that at No. 4. This condition, however, did not occur until about 7 a. m. on the 28th. On the night of the 28–29th, the wind changed to light southeast and east, causing a moderate inversion, which

resulted in reducing the minimum at No. 1 to a point 12° lower than No. 2 and 10° lower than No. 4. The vertical temperature gradient at midnight is shown in Figure 63 by the curve marked "Light easterly winds." Note the rapid fall in temperature at No. 1 in the graph (fig. 62) during this night as compared with the gradual fall at the same station on the preceding night, when the falling curves of temperature at both Nos. 1 and 4 are nearly parallel until about 6 a. m.

The thermal belt at Tryon is built up to an unusual height on inversion nights during the prevalence of light southeast or southerly winds, as the cold air is then pocketed in the gorge above No. 1 and is only slightly disturbed by the moderate flow of air above it. No. 1 then continues to lose heat by radiation until a considerable inversion is formed, as, of course, the temperature at Nos. 2, 3, and 4 is, under these conditions, quite high, the slope being warmed by the free air brought to it by the southeasterly winds. At these times, the highest temperature is often found at No. 4 or even on the very summit of Warrior Mountain, 400 feet above No. 4 and over 1,000 feet above No. 2, where the center of the thermal belt on this mountain is usually found, showing that under the most favorable conditions the thermal belt at Tryon reaches to a considerable height.

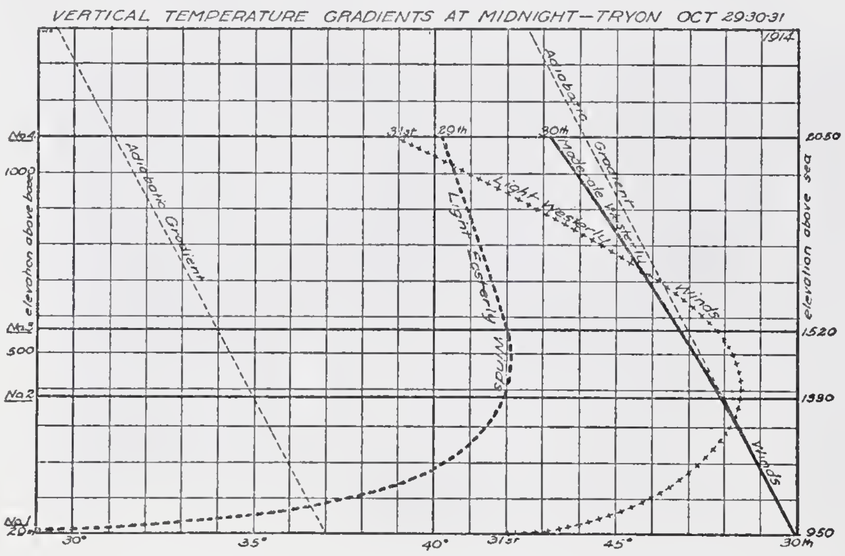

FIG. 63.—Vertical temperature gradients under varying conditions, October 29–31, 1914.

Returning now to the discussion of Figures 62 and 63, it is noted that in the former a sudden fall in temperature occurred at No. 1 on the 29th, shortly after 4 p. m. This drop was caused by a change in the direction of the wind to the northwest. During the night of the 29th–30th the northwest winds increased in velocity, thus aiding in the development of the mountain breeze, which caused a sharp rise in temperature at No. 1 at 10 p. m. Moreover, the general westerly movement of the air was of such strength during the night that a cold descending current from the Saluda plateau was felt at the other stations, especially at No. 4, where the hourly readings were unusually low during most of the night. On clear nights, such as the one in question, with the breeze blowing at No. 1, it is often noticed that No. 4 is much too cold considering the difference in elevation, and this is probably accounted for by the fact that the general air movement from a westerly direction, which seems necessary for the full development of the mountain breeze, descends through the warmer air on the eastern slope of Warrior Mountain and reduces the temperature on the slope, although being warmed itself by the same process. The weight of the descending cold air mixing with the previously warm air on the slopes, forces it downward, which in turn, from the pressure behind it, displaces the cold air at the bottom of the valley, and it is only under these conditions—that is, when the air movement from the west is strong enough to push the cold surface air of the plateau over the summit of Warrior Mountain—that a descending air current is felt at all three stations, Nos. 2, 3 and 4. This combination of a strong mountain breeze at No. 1 and strong descending currents down the slope of Warrior Mountain occurs only infrequently and is seldom shown by the minima at the slope stations, Nos. 2 and 3. While the influence of the mountain breeze passing down the gorge of the Pacolet prevents the temperature from falling at No. 1, and even causes it to rise, the cold air descending from the plateau down the slope of Warrior Mountain is not sufficiently warmed through compression to prevent the temperature there from falling. This combination is only temporary and generally lasts but a few hours. An excellent example of this condition is shown in Figure 62 on the night under discussion, October 29–30, when from 11 p. m. to 4 a. m., the temperature at No. 2, the center of the thermal belt, was continually lower than No. 1 at the hour of 3 a. m., the difference being nearly 5°. After this hour the wind diminished, and the temperature at No. 1 therefore fell to a point below No. 2. The vertical temperature gradient on this same night at midnight is shown in Figure 63 by the black line marked "Moderate westerly winds," which closely follows the adiabatic gradient represented at the left by the straight line. These descending currents on Mount Warrior have little or no effect upon the temperature at No. 1, which is entirely under the influence of the brisk wind which sweeps out from the gorge of the Pacolet valley, the temperature of the valley floor being regulated by conditions which differ widely from those on the steep easterly slope of Warrior. For these reasons it is rather difficult to compare No. 1 on the valley floor with the three upper stations on the slope. If the upper stations were situated in the gorge of the Pacolet in a line with No. 1, we would often find a gradual decrease in temperature with elevation, but instead they are located in a sheltered position on the eastern wall of the inclosing Blue Ridge and normally little affected by the breeze.

After the mountain breeze is fully developed, the considerable mixing of the air will give a vertical temperature gradient on the slope corresponding nearly to the adiabatic rate, as brought out in the preceding paragraph, but as the temperature falls lower and lower on the Saluda plateau as the night proceeds, this flow of cold air descending the slope gradually lowers the temperature at No. 4 at a corresponding rate. But since the volume of cold air forced over the edge of the plateau is small when light westerly winds prevail, it does not descend the slope of Warrior Mountain in sufficient quantity to force its way to the bottom; hence the temperature at only Nos. 4 and 3 is lowered, the readings at the latter station being but slightly affected, while the relation of the minima at Nos. 2 and 1 is similar to that under inversion conditions, except that the reading at the latter station is relatively high. Thus at sunrise, for instance, the temperature gradient may be strongly superadiabatic, and this relation, especially between Nos. 2 and 4, is not uncommon at any hour of the night. It is well shown in figure 63 by the black line marked "Light westerly winds," which represents the gradient at midnight of October 30–31. During this night a true mountain breeze prevailed, with light westerly winds, and the temperature at No. 1 fluctuated considerably, although

with a falling tendency, but it was undoubtedly prevented from falling to as low a point as it otherwise would had no breeze occurred. In figure 62, note the relatively high temperature at No. 2 as compared with the readings at both Nos. 1 and 4 on that night, resulting in the marked superadiabatic gradient shown in figure 63.

Isopleths showing progressive distribution of temperature during a May period of inversion at Ellijay.—The isopleth (fig. 64) shows the progressive distribution of average temperature on the slope at Ellijay during a typical six-day period in May, 1914. During the daylight hours we find a normal decrease in temperature due to elevation continuing until about 5 p. m., when the sun's rays are shut off at station No. 1 by intervening mountains, although they are still effective on the remainder of the slope. A rapid loss in heat occurs at this time at No. 1 and a loss also, although in a much less degree, at Nos. 4 and 5, while the more effective insolation at Nos. 2 and 3 delays the rapid fall in temperature at those stations—in fact, nearly an hour in the case of No. 2. The point of highest temperature appears successively at the stations in order of their increase in elevation, but during this period it never reaches No. 5. However, more complete observations on the slope, if available, would undoubtedly show that the average highest minima during the week in question occurred at a point about midway between Nos. 4 and 5. This successive rise in the position of highest minima with increasing elevation is partially due to the shutting off of the sun's rays, but mainly to the reshaping of the vertical temperature gradient with the more rapid loss in heat at the lower stations.

About 4:30 a. m. the largest inversion occurs, averaging 15.8° between Nos. 1 and 4. Note the rapid rise in temperature during the early morning hours at the lower stations, especially at No. 1, the temperature at the base reaching about the same degree as at No. 5 shortly before 8 a. m., at which hour the temperature averages about 6° lower at No. 2 than at No. 1. No. 2 is the last station at which the temperature begins to rise in the morning, because the sun's rays reach this location on the slope later than at any other point. By 9 a. m. the normal decrease in temperature with elevation prevails, this continuing until the late afternoon, when the same processes are repeated on nights favorable for inversions. If the weather conditions are stable and purely anticyclonic and the absolute humidity low, the successive appearances of this relatively warm belt at increasing elevations are so rapid that they are difficult to follow, but during more humid weather the change can be traced quite easily, and often the rising sun of the following morning finds the belt below the normal height (see Table 17).

Mean minimum temperatures during inversion weather at 14 base stations corrected for latitude and to the 2,000-foot level.—We have seen in the preceding paragraphs the marked influences of topography during nights of inversion, resulting in great differences in minima at points having approximately the same elevation. Some base stations are relatively colder than others, just as there are variations between the minima at slope stations and between those at summit stations. The temperature at the summit depends largely upon the surrounding surface area, and that on the slope upon its direction and steepness, as well as the proximity to opposing slopes. However, there is naturally a difference of opinion as to the kind of base station that insures the lowest minima during nights of inversion. The term "frost pocket" is often used without any special reference to the character of the surrounding topography, and the fact that low minima occur at such a place, with resulting serious damage during frosty nights, is usually considered sufficient to justify the appellation. However, there are different kinds of frost pockets, and an attempt will be made here to point out the features that have the most important bearing upon the situation.

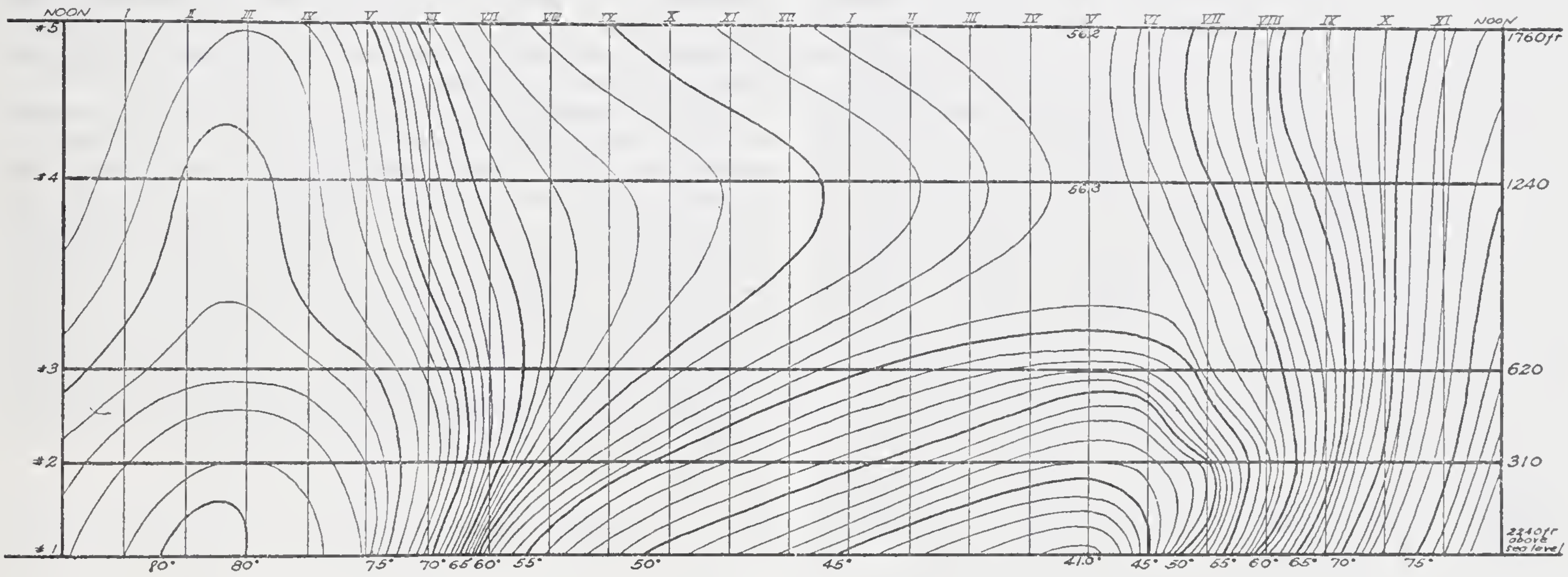

FIG. 64.—Isopleths, selected inversion period, May, 1914, Ellijay.

In Table 19, used in this comparison, a correction has been applied to the base station readings for both elevation and latitude, the stations being reduced to a common base of 2,000 feet above sea level, and to a latitude of 35° north. The elevation of 2,000 feet is selected, as that represents approximately the average of all the base stations employed in the research, and the parallel 35° passes along the southern border of the region.

In order to make the reductions for elevation, a correction of 1° for each 300 feet has been applied to the observed minima. The vertical temperature gradient is greater in summer than in winter, so that the correction of 1° for 300 feet is probably insufficient during the warmer months of the year, too large for the winter months, and near the true correction for the spring and

autumn months and for the year as a whole. The correction for latitude applied varies with the season of the year, at the more northerly points approximately 1.2° in summer, 2° in spring and autumn, 3° in winter, and 2° for the means of all four seasons, which represent annual values. In contrast with these the more southerly stations have practically no corrections for latitude, while those midway have intermediate values. Reductions of this kind can not be made with any refinement, but it is thought that the comparison would not be satisfactory without some correction, so as to reduce approximately the readings to a common basis.

For the purposes of this comparison periods of inversion are selected for each month of the year, as well as extra periods for May and November, double weight being given to these months on account of the greater frequency of inversions. Table 19, which contains these values, furnishes most interesting results. In the spring, summer, and autumn the base stations at Highlands, Bryson, and Blantyre are seen to be the coldest, the Highlands station being especially the coldest in the summer. This station is located in the saucer-shaped depression so often referred to, with a slope to the northwest on which the orchard stands, and dense surrounding timber in all other directions. The situation is such at this point that there is practically no opportunity for interchange with the warm free air, nor is there ever a mountain breeze possible from the slope above during nights of inversion. Moreover, during the seasons of the year when the foliage is dense, especially in summer, the air is trapped by the dense timber, and the cold air accumulates in large quantities. While Highlands No. 3 appears in Table 19 as the coldest of the base stations during spring, summer, and autumn inversions, several base stations in winter have lower corrected minima. The trees in the vicinity of the Highland station are deciduous, and the frost pocket is therefore not so pronounced in the winter, as the timber then does not serve as a barrier to the movement of air out of the pocket, as it does in summer. The situation at Bryson and Blantyre, the two other base stations having abnormally low minima, is much different from that at Highlands. Bryson and Blantyre are both situated close to wide valley floors, where the air movement is reduced by surrounding mountains, but not close enough to interfere with radiation, and with considerable marsh land and dense vegetation surrounding, from which loss of heat by radiation is rapid during nights of inversion. There is, in fact, no obstruction to radiation at either of these two base stations, and doubtless on the very floor of the valley at Blantyre the minima would be even lower than at station No. 1, which is slightly above on a terrace. Thus we have a small frost pocket at Highlands and large ones at Bryson and Blantyre of an entirely different character, but which may nevertheless be called true frost pockets in spite of their large area.

Gorge and Ellijay, moreover, are rather cold points, and while the topography at these two places is much unlike that at Highlands, Bryson, and Blantyre, where the lowest temperatures of the entire region are registered, the low minima at Gorge and Ellijay are due largely to stagnation, having higher elevations in close proximity on all sides, although this condition serves at the same time to limit the opportunities for free radiation. Again, at the summits of these five slopes, all of which culminate in knobs, the surface area is not great, and there is no development of a mountain breeze downward, with consequent rise in temperature on the valley floors, as may be found at Tryon and Blowing Rock, for instance. Blowing Rock No. 3, while often referred to as a frost pocket having consistently low temperatures throughout the year because of its elevation, nevertheless is so frequently favored by a breeze at night during periods of inversion that its minima average much higher than other stations where conditions would seem more favorable. Along the summit of the orchard in which No. 3 is located there is a considerable area, and below the station there is an outlet, thus permitting the breeze to pass down the valley of the New River and thus raising the temperature mechanically at the valley floor station.

During inversion nights unfavorable for the breeze at Blowing Rock, when the trend of the air is from the southeast, minima are observed at station No. 3 as low as at any base station in the entire region and sometimes even lower and it is only because of the breeze during certain nights that the average minima there are so high as compared with those at other base stations.

The base stations not located on true valley floors, such as those at Transon, Asheville, and Mount Airy, have the highest corrected minima, if Blowing Rock and Tryon be excepted. The Tryon station, of course, has a position on a true valley floor, but its comparatively high minima are due to the night breeze, as previously described, and also to the relatively greater vapor pressure in its lower position.

Table 19 certainly shows great variation in these corrected minima. Bryson for both the year and the winter season has the lowest minima and Mount Airy the highest, with average differences between them, respectively, of 9.8° and 9.7°. Highlands has the lowest in the spring, summer, and autumn, as stated previously, Mount Airy the highest in spring and autumn, and Tryon the highest in summer, Highlands averaging 12.3° lower in spring and autumn and 12.6° in summer. These large differences in temperature fairly represent the varying effect of topography and vegetation and indicate that there are great variations in base station readings of the same elevation and latitude.

TABLE 19.—*Average minimum temperatures during inversion weather at 14 base stations, corrected for latitude and to the 2,000-foot level.*

[The temperatures are corrected for latitude 35° north. In reducing for elevation 1° is allowed for each 300 feet of increase in elevation. The elevation of 2,000 feet represents approximately the average elevation of the 14 base stations used in the table.]

Order.	Station.	Temperature.	Order.	Station.	Temperature.
	SPRING AND FALL.			WINTER	
1	No. 3, Highlands	36.4	1	No. 1, Bryson City	24.1
2	No. 1, Bryson City	37.5	2	No. 1, Blantyre	24.4
3	No. 1, Blantyre	37.6	3	No. 1, Gorge	26.1
4	No. 1, Hendersonville	39.3	4	No. 1, Ellijay	26.7
5	No. 1, Gorge	39.5	5	No. 1, Hendersonville	27.2
6	No. 1, Cane River	39.5	6	No. 3, Highlands	27.5
7	No. 1, Ellijay	39.9	7	No. 1, Cane River	27.2
8	No. 1, Wilkesboro	43.0	8	No. 1, Wilkesboro	28.6
9	No. 1, Transon	43.6	9	No. 1, Globe	29.7
10	No. 1, Globe	44.0	10	No. 1, Tryon	29.8
11	No. 1, Ashevillo	44.9	11	No. 1, Transon	32.3
12	No. 1, Tryon	45.5	12	No. 3, Blowing Rock	33.0
13	No. 3, Blowing Rock	45.7	13	No. 1, Asheville	33.0
14	No. 1, Mount Airy	48.7	14	No. 1, Mount Airy	33.8
	SUMMER.			ANNUAL.	
1	No. 3, Highlands	46.8	1	No. 1, Bryson City	36.1
2	No. 1, Bryson City	49.4	2	No. 3, Highlands	36.2
3	No. 1, Blantyre	49.8	3	No. 1, Blantyre	36.4
4	No. 1, Ellijay	49.9	4	No. 1, Gorge	38.0
5	No. 1, Cane River	50.4	5	No. 1, Ellijay	38.0
6	No. 1, Hendersonville	51.0	6	No. 1, Cane River	38.3
7	No. 1, Gorge	51.3	7	No. 1, Hendersonville	38.3
8	No. 1, Transon	52.9	8	No. 1, Wilkesboro	40.4
9	No. 1, Wilkesboro	53.9	9	No. 1, Globe	41.7
10	No. 1, Asheville	53.9	10	No. 1, Transon	42.1
11	No. 1, Globe	54.0	11	No. 1, Asheville	43.2
12	No. 3, Blowing Rock	55.4	12	No. 1, Tryon	43.8
13	No. 1, Mount Airy	58.1	13	No. 3, Blowing Rock	43.9
14	No. 1, Tryon	59.4	14	No. 1, Mount Airy	45.9

Approximate vertical temperature gradients during typical periods of inversion.—The graph (fig. 65) shows the approximate vertical temperature gradients of the free air over a plain as constructed from the average minimum temperatures for the two periods of typical inversion weather, May 1–6, 1913, and November 2–5, 1916, used in Table 2a. The free-air curves are represented by the two heavy black lines at the right and are based upon data for the following summit or high slope stations:

Stations.	May period.	November period.
Mount Airy No. 4	A	A′
Gorge No. 5	B	B′
Globe No. 3	C	C′
Hendersonville No. 4	D	D′
Transon No. 4	E	E′
Ellijay	F	F′
Ellijay No. 5		F″
Cane River No. 4	G	G′
Highlands No. 5	H	H′

ascent) and the adiabatic gradient (1.6° for each 300 feet) are shown by the dotted lines for comparative purposes in connection with the temperature gradients on the selected slopes.

The individual vertical temperature gradients for seven selected slopes, including that in the Waldheim orchard at Highlands, for both periods, May and November, are shown in the graph at the left of the free-air curves and are illustrated by lighter curved lines. These gradients are most interesting, and, although there is a marked similarity in the May and November curves, the differences are due to differences in the direction of the air movement prevailing during the periods selected.

In calm anticyclonic weather the mountain breeze is the rule at Tryon, although some periods are more favorable for its development than others. The May period selected is slightly unfavorable in that light southeast to south winds prevailed on the nights selected,

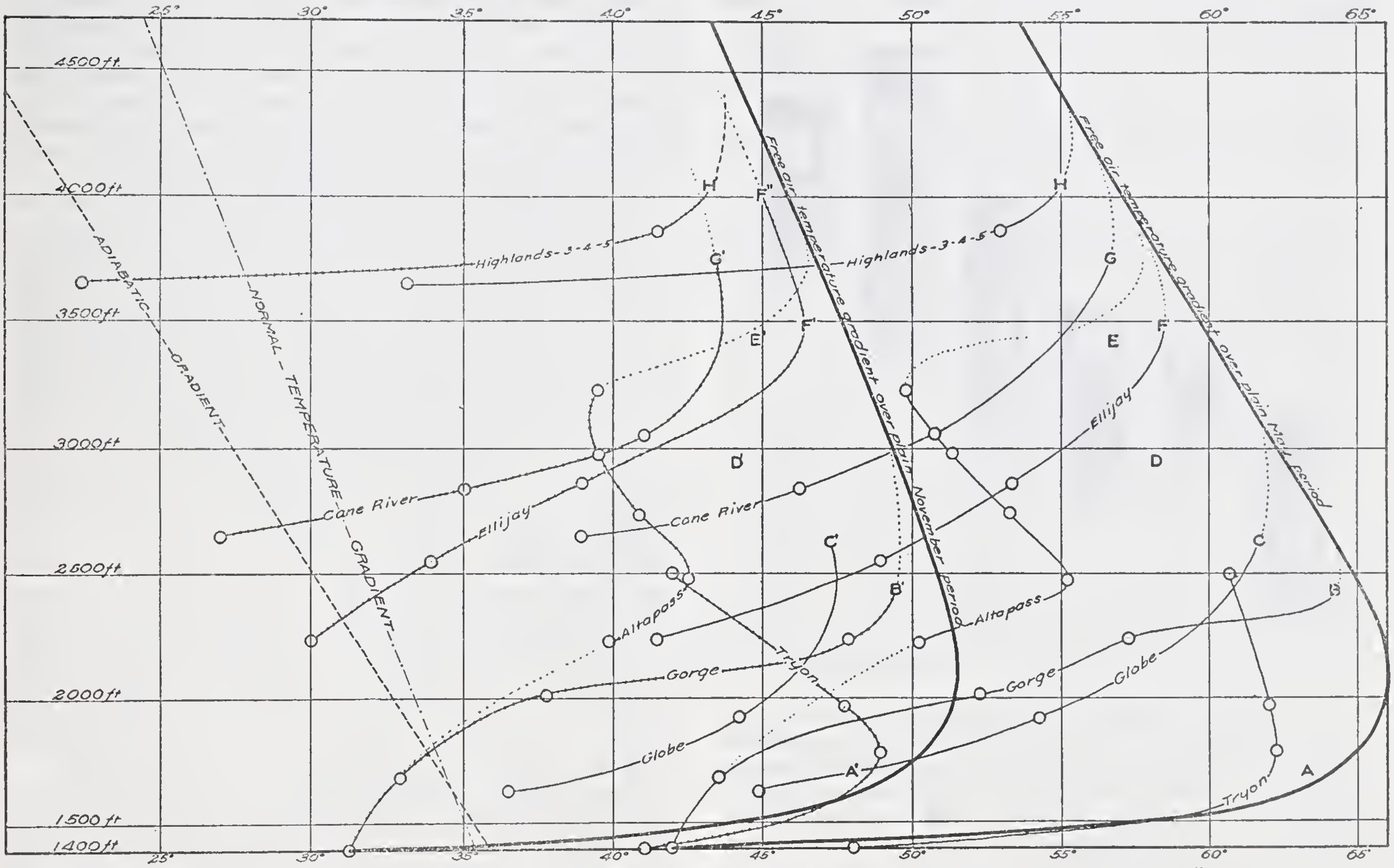

FIG. 65.—Approximate free-air temperature gradients over western North Carolina during periods of inversion in spring and fall.

These stations are selected as representing, within 5° or so, the temperature of the free air on inversion nights at their respective elevations. The free-air curves for each period are drawn from the base station at Tryon, but as the average for this elevation does not represent a typical reading on account of the frequency of the mountain breeze the average minimum temperature for Gorge No. 1, reduced to that elevation, is used as the surface temperature for that altitude.

These curves have been drawn somewhat to the right with reference to the selected stations, since even the most ideal slope station during a night of inversion would have a lower temperature than the adjacent free air.

At the left in the graph the normal decrease in temperature with elevation in free air (1° for each 300 feet of

thus having a tendency to hold back the accumulated cold air on the plateau. The November period happens to be extremely favorable, with a predominance of air movement from the northwest. The curve for the May period, therefore, more nearly resembles the heavy curve, while the November gradient is strongly superadiabatic after passing No. 2, with the waterlike descent of cold air on No. 4 from the plateau above.

The two curves for Globe differ considerably, the temperature of No. 1 during the November period being unusually high for its elevation. The position of this station is well located topographically to experience a mountain breeze, yet the actual occurrence of the breeze is both infrequent and of short duration. It is also not a typical valley-floor station in that the profile

of Gragg Fork, where the station is located, shows a considerable inclination as compared with that of the valley floor at Gorge, for instance, Globe No. 1 having a better air exchange than most valley floor stations. Again, the available sky room for radiation is considerably cut down by the near approach of the opposing steep slopes.

The curves at Gorge are irregular and of unusual contour, and this is because of the unusually low temperatures at the lower stations due to the confining walls, while the minima at the upper stations are high.

The curves for Altapass for May and November are much alike, but quite dissimilar to the free-air curve. The five stations here are on a steep slope near a gorge which has been cut back into the Blue Ridge plateau, so that on a calm clear night we find a great accumulation of cold air over the plateau and directly over the slope on which the orchard stations are located. The descent and mixing of this cold air with the warm free air in the valley reduces the temperature of the whole slope, and although the usual thermal conditions are displayed on the slope, yet there is a considerable reduction of the temperature on the entire slope, referred to on a previous page. If these curves were continued below station No. 1 to substation No. 1a, they would be approximately parallel to those at Gorge.

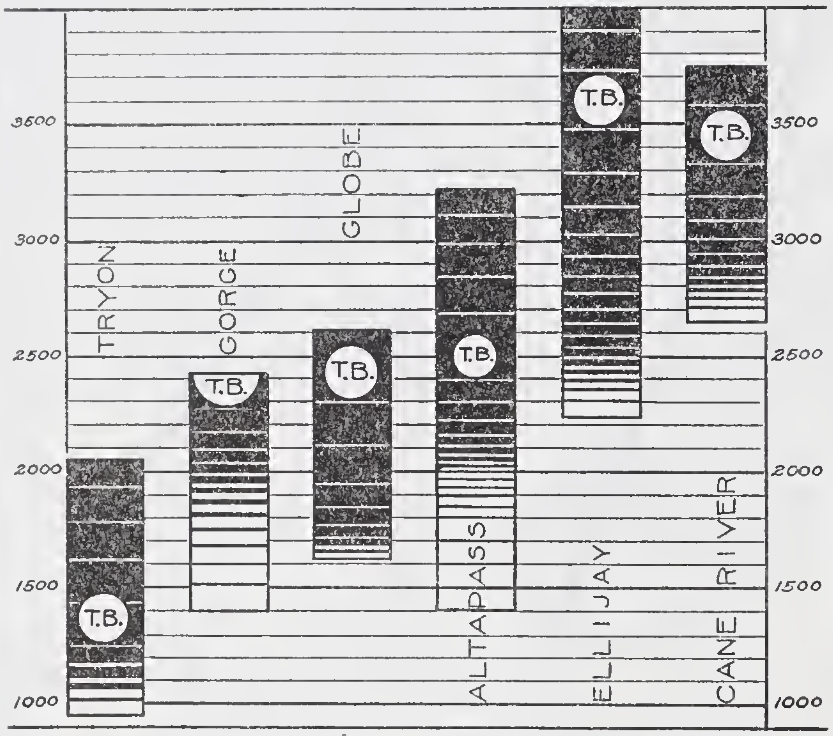

Fig. 66.—Average position of thermal belt on six long slopes during typical inversion weather.

For both periods at Cane River the curves are quite similar, except that in the November period, the temperature at No. 4 appears relatively lower than in May because of the prevailing northerly winds in November, which serve to bring warm free air to the slope stations lower down.

At Ellijay the summit station was not in operation in May, 1913, so that the complete curve for the selected period in that month is not shown, but in the autumn period the curve is ideal after No. 3 is reached, as then the temperature of the slope partakes more and more of that of the free air which at the elevations of Nos. 4 and 5 is available in large quantities with decreasing surface area.

The curves at Highlands naturally show the markedly low temperatures prevailing at the base station, No. 3, in the Waldheim orchard and the large differences between it and No. 4, and are quite similar for both selected periods, as wind direction and velocity have no effect upon the temperature conditions on this slope.

The vertical temperature gradient is more nearly adiabatic in summer than in winter, and the constructed free-air curves shown in Figure 65 for the May and November periods conform to this seasonal difference.

HEIGHT OF THERMAL BELT.

Average position of the center of thermal belt on nights of inversion.—Figure 66 shows the average position of the belt of highest temperature on typical nights of inversion on the six slopes having a range in vertical height from 1,000 to 1,760 feet, Altapass, Cane River, Ellijay, Globe, Gorge, and Tryon. In this figure the shaded columns represent the vertical height of the various slopes and their relative elevation. The circle marked "T. B." indicates the average position of the thermal belt during typical periods of inversion weather. The density of shading shows the relative warmth on various portions of the slopes. The Altapass slope in the figure includes not only the five experimental stations, but also the remainder of the slope below station No. 1 down to the valley floor at No. 1a, conforming to the plan discussed on a former page, when a comparison of thermal conditions was made between Altapass and Ellijay.

The main factors determining the height of this belt are the inclination or grade of the slope and the surface area at the summit. The direction of air movement is often quite important, as, generally speaking, exchange between the slope and the warm free air facing it is hindered on the lee side and aided on the windward sides, cold air accumulating on the slope on the lee side, with a lowering of the temperature and a corresponding raising of the center of the thermal belt, while on the windward side the temperature is raised by the constant inflow of warm air on the slope, with a consequent lowering of the center of the thermal belt, although the width or extent of the inversion is not necessarily decreased. On the southeast slope of Tryon, for instance, under the influence of southeast winds, while the point of highest minimum lies relatively near the base station, the thermal belt or inversion may extend upward to No. 4 station, and even considerably beyond. Of course, in such event the temperature gradient from the point of highest minimum upward is very slight as compared with the gradient between this point and the base station, and the actual center of the thermal belt does not necessarily coincide with the point of highest minimum.

Then there is a tendency during protracted periods of anticyclonic weather with a night or so of absolute calm for the belt to be pushed upward by the failure of the usual relief of the unstable conditions existing between slope and free air. The inflow of warmer air with the approach of a low-pressure area is first felt at the more elevated stations, and in extreme cases the temperature may be rising at the summit station and falling rapidly at the levels below, because of the reduction of wind velocity in the valley by surface friction. The belt is thus forced to unusual heights and is higher with increasing length of night. We would expect this belt to be lowest over a plain where the radiation is confined to a level surface over which a stratum of cold air is built upward by loss of heat from the ground, gradually affecting successive layers of air above, and highest in a deep and narrow valley where the volume of air is reduced and the radiation from the opposing slopes in cooling the air in contact with them drains the small amount of air between the slopes of its warmth.

At Tryon we may find the belt between Nos. 2 and 4, but most frequently near and above No. 2, at an elevation of about 400 feet above No. 1. The vertical temperature gradient at Tryon (see fig. 65) very closely resembles that over a plain as there is no opposing slope. During the occurrence of the mountain breeze the belt is forced downward by the waterlike flow of cold air from the plateau where it has accumulated. The three slope stations at Tryon are not directly in the path of the mountain breeze, and the small quantity of cold air which is forced over the summit of Warrior is quickly warmed by mixture with the air on the slope and by compression in its descent, and usually it merely chills No. 4 and possibly the slope a few hundred feet below, with a consequent slight lowering of the belt. It is under these conditions that the vertical temperature gradient becomes strongly superadiabatic between Nos. 2 and 4 (see fig. 63). Under favorable conditions, previously described, the upper portion of the thermal belt may be so extended as to include the summit of Warrior above No. 4, although the highest minimum will still be recorded at No. 2.

The temperature of the free air at Altapass is much reduced by the large area of the radiating surface of the surrounding country. The Blue Ridge plateau, nearly flush with the surrounding rim of mountains, is a source of much of the unusual coolness of the slope stations as compared with others of the same elevation both above sea level and their respective valley floors. However, since the entire slope seems to be affected by this unusual environment, as well as the adjacent free air, the belt of highest temperature, at least within the limits of observation, is found to have practically the same elevation, as at Globe and Gorge, and this condition is well shown in the following table, the center of the belt in each case being approximately 1,000 feet above the floor:

	Elevation of valley floor.	Average elevation of belt of highest temperature.
	Feet.	*Feet.*
Gorge	1,400	2,440
Altapass	1,500	[1] 2,480
Globe	1,625	[1] 2,625

[1] Approximately.

At Ellijay we have the extreme condition of a narrow and deep valley and reduced available free air, and it is not until an elevation of 1,250 feet above the valley floor and nearly 3,500 feet above sea level is reached that warm free air in considerable quantities is available, approximately the level of station No. 4, and because of this fact and the steadily decreasing surface area, the average height of the belt is placed somewhat above No. 4.

At Cane River warm free air is available in considerable quantities above the 3,000-foot level 350 feet above the valley floor, and the belt of highest temperature shifts between Nos. 3 and 4, depending upon the wind direction. No. 3, which is in a cove-like depression on the side of Rocky Knob, is colder than points of similar elevation on the open slope. The 700-foot difference in elevation between Nos. 3 and 4 does not permit an accurate location of the belt, and although quite frequently the highest temperature recorded on the slope is found at both Nos. 3 and 4, especially with air movement from the north, the more rapid recovery at the higher station after a cold spell forces the belt to the summit regardless of the wind direction. Thus the average position is placed slightly below No. 4.

Seasonal fluctuation of the thermal belt.—In an attempt to determine whether or not there is a seasonal fluctuation in the height of the thermal belt on account of difference in length of nights, a comparison has been made on the Ellijay and Tryon slopes, having vertical heights of 1,760 and 1,100 feet, respectively, for which figures are given in Table 20 for the spring and autumn. The center of the thermal belt at Ellijay ordinarily fluctuates between stations Nos. 4 and 5 and at Tryon between Nos. 2 and 3, as has been shown already, so that in this comparison we need only to use the data for the two higher stations at Ellijay, while at Tryon only stations Nos. 2 and 3 are necessary.

The table gives the number of nights during inversions when each one of these stations was the warmest in its group, for the months of April, May, and June, representing the spring, and October, November, and December, representing the autumn. June is used instead of March in the spring group and December instead of September in the autumn group in order to accentuate the differences in the length of nights.

The data are for the four years at Tryon, 1913–1916, but for only three years at Ellijay, as station No. 5 there was not in operation until 1914. A greater number of inversions are found on both slopes in the spring than in the autumn. In the spring the highest minima are observed at station No. 4 at Ellijay, 78 per cent of the total number of nights of inversion, as compared with 22 per cent at No. 5, while in the autumn the percentages are 75 and 25, respectively, indicating a very slight raising of the belt in the autumn. At Tryon in the spring the highest minima observed were 82 per cent of the time at station No. 2, as compared with 18 per cent at No. 3, while in the autumn the percentages were 79 and 21, respectively, the variation between the two seasons being the same as at Ellijay.

The above comparison has been supplemented by the employment of another method, shown in Table 20, May and November only being used. In this method the excesses in temperature at stations Nos. 4 and 5 at Ellijay and at Nos. 2 and 3 at Tryon over No. 1 in their respective groups during all nights of inversion in these two months for the four-year period are included in Table 20, and this comparison shows for Ellijay percentages of 53 and 47, respectively, for May and 52 and 48, respectively, for November, while at Tryon the percentages for May at Nos. 2 and 3 are 57 and 43 and for November 54 and 46, respectively, confirming the results obtained in the first comparison and showing only a slight excess at No. 4 on the Ellijay slope in the spring month of May over that in the fall month of November. The same may be said for station No. 2 at Tryon as compared with No. 3.

We may conclude from these two comparisons that there is a tendency, although slight, for the thermal belt to rise with the increase in the length of nights. We have seen already that the belt on the Ellijay slope ordinarily assumes a high level because of the relatively small area near the summit and the presence of opposing slopes lower down, while at Tryon the point of highest temperature is relatively low because of the great area in the vicinity of the summit and the lack of opposing slopes at the lower levels. At Ellijay, the center of the belt is usually about 1,240 feet above the base station, while at Tryon the highest minima are found at a point 400 to 500 feet above the valley floor, as shown also in a previous discussion.

These two belts are fairly representative of conditions in mountain districts and they indicate the great differences that may exist in the positions of the thermal belts on slopes as modified by surrounding topography.

TABLE 20.—*Seasonal fluctuation of the thermal belt on the two longest slopes, Ellijay and Tryon.*

ELLIJAY (1914–1916).

[Number of days with highest temperature at stations Nos. 4 and 5.]

	April.		May.		June.		Total.		October.		November.		December.		Total.	
	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.	No. 4.	No. 5.
1914	16	1	12	10	15	10	43	21	11	7	7	10	8	4	26	21
1915	19	3	21	2	16	2	56	7	10	3	18	3	18	3	46	9
1916	15	4	15	7	16	3	46	14	12	8	[1]12	[1]0	19	1	43	9
Total	50	8	48	19	47	15	145	42	33	18	37	13	45	8	115	39
Per cent							78	22							75	25

TRYON (1913–1916).

[Number of days with highest temperature at station No. 2 or No. 3.]

	April.		May.		June.		Total.		October.		November.		December.		Total.	
	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.	No. 2.	No. 3.
1913	12	7	18	6	22	9	52	22	18	4	18	5	14	4	50	13
1914	15	6	21	5	22	2	58	13	17	11	21	9	7	2	45	22
1915	21	5	22	2	17	4	60	11	12	2	18	2	16	2	46	6
1916	21	2	25	4	26	2	72	8	24	4	22	3	13	4	59	11
Total	69	20	86	17	87	17	242	54	71	21	79	19	50	12	200	52
Per cent							82	18							79	21

MONTHLY TOTALS, IN DEGREES OF INVERSION EXCESS, OF STATIONS NOS. 4 AND 5 OVER NO. 1 AT ELLIJAY AND OF STATIONS NOS. 2 AND 3 OVER NO. 1 AT TRYON.

	Ellijay.				Tryon.			
	May.		November.		May.		November.	
	No. 4.	No. 5.	No. 4.	No. 5.	No. 2.	No. 3.	No. 2.	No. 3.
1913					186	158	248	228
1914	273	264	278	292	203	160	213	188
1915	167	129	198	169	119	74	243	194
1916	229	208	[1]108	[1]85	205	136	177	134
Total	669	601	584	546	713	528	881	744
Per cent	53	47	52	48	57	43	54	46

[1] Twelve days missing.

TOP FREEZES AND NORMS.

The subject of inversion has now been discussed at considerable length, and that portion of the investigation furnishes most interesting data and certainly the greatest complications. Inversion conditions are, of course, most important when frost occurs in the lower levels, and this situation has much influence upon the raising of fruit. When the temperature in the lower levels does not fall sufficiently low for the formation of frost, the degree of inversion is of much less consequence.

There is another phase of the study of much interest—the decrease in temperature with elevation; and we will refer to this subject under the heading "Top freezes and norms." The expression "Top freeze" is employed in the mountain region to designate a freezing condition in the upper levels that may or may not extend down the slope to the valley floor, but in any case the temperature is lowest at the summit. Top freezes are included in norms, but there are many cases that we shall have to consider where the temperatures are not below the freezing point, although still with approximately the same decrease with elevation. The term "norm" has been used in previous chapters of this publication and it seems to be acceptable, as the word indicates the return to what may be considered approximately normal or natural conditions.

The subject was touched upon on previous pages in connection with the study of average minimum temperature, and it was shown that during the selected norm periods (fig. 49) the minimum temperature decreased more or less regularly from the lowest to the highest levels and that the rate of decrease between the lowest and highest stations employed in the research, Tryon No. 1 and Highlands No. 5, was 1.2° for each 300 feet of ascent, as compared with a normal decrease of 1° for each 300 feet in free air.

An examination of the observations on the long slopes during the research shows marked instances of norms, as well as of inversions, during the winter months, but they are relatively less frequent during the other seasons of the year. Naturally norms on short slopes are of little consequence. The forms containing the observations at Ellijay during certain selected months, January, 1916, February, 1915, and March, 1916, Tables 11, 12, and 21, respectively, embrace fairly representative conditions for these particular months. Ellijay is the longest slope used in the study, 1,760 feet, and the observations on that slope bring out the features of norms strongly, just as they do of inversions. Of course, there is not the same range in norms that there is in inversions, the decrease seldom reaching 10°, while inversions may often exceed 20°, as shown in Table 7. Norms ordinarily occur during cloudy weather, with rather strong winds between southwest and north, such as ordinarily usher in cold weather. If the weather is clear, there is a tendency to inversion, although, if the wind is sufficiently brisk, this tendency is neutralized. In Table 21, March, 1916, at Ellijay there are 18 instances of norms, as shown by a comparison of the summit with the base station, but in no case is there a greater range than 11°. In January of the same year (Table 11) there are 19 instances of norms, with the greatest range reaching 10°, and in February, 1915 (Table 12), only 11 instances, the greatest range being as small as 7°. These three months are fairly typical of conditions in the colder months of the year. In the above figures dates having norms as small as 1° even are included, although this rate, considering the differences in elevation, is well-nigh inappreciable.

It may be said that a norm is characteristic of a change to colder weather when the wind velocity is sufficiently strong to prevent inversion, the amount of difference in temperature between the summit and base stations depending almost wholly on the differences in topography. Norms do not occur always in cloudy weather, as cloudiness is sometimes characteristic of the Intermediate or Cyclonic Type of inversion when there is an overrunning of warmer air either immediately after the passage of the anticyclone or directly before the arrival of the low-pressure area.

TABLE 21.—*Monthly record of minimum temperatures, daily precipitation, wind direction and force, and state of weather, also differences between readings at base station and those on slope, March, 1916, Ellijay, selected month showing norms.*

[The differences between readings at the base and the respective slope stations may be seen by inspection.]

Date.	Temperature.					Precipitation at 6 p. m. (inches).	Wind.				State of weather.	
	Station 1, base.	Station 2, N., 310.[1]	Station 3, N., 620.[1]	Station 4, N., 1,240.[1]	Station 5, 1,760.[1]		Sunrise.		Sunset.		Previous night.	Day.
							Dir.	Force.	Dir.	Force.		
1...	21	23	22	23	23	0.00	sw.	Mod...	sw.	Mod...	Cloudy..	Cloudy.
2...	32	31	32	31	29	0.36	w.	...do...	w.	Brisk.	...do.....	Clear.
3...	26	22	20	18	19	0.00	nw.	Brisk.	nw.	...do...	...do.....	Cloudy.
4...	10	11	10	9	7	0.01	nw.	Mod...	nw.	Mod...	...do.....	Clear.
5...	25	31	31	32	28	0.00	w.	...do...	w.	...do...	Clear....	Do.
6...	36	41	41	45	41	0.00	sw.	Brisk.	sw.	Brisk.	Cloudy..	Cloudy.
7...	46	44	44	45	39	0.42	w.	...do...	nw.	...do...	...do....	Pt.cldy.
8...	21	19	16	13	13	0.00	nw.	...do...	nw.	...do...	Pt.cldy.	Cloudy.
9...	11	13	11	8	7	T.	w.	...do...	w.	Mod...	Cloudy..	Clear.
10...	22	24	26	26	21	0.00	w.	...do...	w.	Brisk.	Clear....	Cloudy.
11...	23	25	24	22	18	0.00	w.	...do...	w.	Mod...	...do.....	Clear.
12...	19	21	22	23	18	0.00	w.	Mod...	w.	...do...	...do.....	Do.
13...	29	35	37	41	33	0.00	w.	...do...	w.	Brisk.	...do.....	Do.
14...	39	46	51	52	49	0.00	w.	Brisk.	w.	...do...	...do.....	Do.
15...	30	28	25	23	23	0.25	w.	Gale..	nw.	...do...	Cloudy..	Cloudy.
16...	10	12	9	6	4	0.00	nw.	Brisk.	nw.	Mod...	...do.....	Clear.
17...	17	19	20	19	16	0.00	nw.	Mod...	nw.	...do...	Clear....	Do.
18...	25	28	30	37	32	0.00	w.	Brisk.	w.	Brisk.	...do.....	Do.
19...	48	45	43	43	37	0.00	w.	...do...	w.	...do...	...do.....	Do.
20...	31	33	30	35	33	0.00	nw.	Mod...	nw.	...do...	...do.....	Do.
21...	41	42	39	40	38	0.26	nw.	Brisk.	nw.	Mod...	Cloudy..	Pt.cldy.
22...	54	59	55	55	50	0.00	nw.	...do...	w.	High..	...do.....	Cloudy.
23...	26	28	27	28	29	0.00	w.	...do...	w.	Brisk.	Clear....	Clear.
24...	39	46	44	46	42	0.00	w.	...do...	w.	Mod...	...do.....	Do.
25...	47	54	52	54	49	0.00	s.	Mod...	sw.	...do...	Pt.cldy.	Do.
26...	57	58	56	56	51	0.00	sw.	...do...	s.	Brisk.	Cloudy..	Cloudy.
27...	40	42	37	44	42	1.17	w.	Brisk.	w.	Mod...	...do.....	Do.
28...	36	35	34	33	29	0.02	nw.	...do...	nw.	Brisk.	...do.....	Do.
29...	35	33	31	29	27	0.00	n.	Mod...	n.	Mod...	...do.....	Pt.cldy.
30...	29	30	32	35	32	0.00	ne.	...do...	nc.	...do...	Clear....	Clear.
31...	31	35	36	40	40	0.00	w.	...do...	w.	Brisk.	...do.....	Do.
Sum.	956	1,013	987	1,013	915	2.49	....	....	....	....	....	....
Mean	30.8	32.7	31.8	32.7	29.5	....	....	....	....	....	....	....

[1] Direction of slope and elevation of station above base station.
Mod.=moderate; Lt.=light; Pt.=partly.

Norms on selected long slopes having a vertical height of 1,000 feet or more.—Table 22 presents norm data for the six long slopes, Altapass, Cane River, Ellijay, Globe, Gorge, and Tryon, including comparisons of frequency and range of norms, after the plan of the discussion of inversions on the basis of 5° or more range in temperature (Table 13), but Table 22 has not been supplemented by additional tables in order to show greater norms, because the range between base and summit seldom equals 10°. In fact, the record norms for the four-year period, as shown in the summary of the table, are as follows: Altapass 8°; Cane River, 10°; Ellijay, 11°; Globe, 8°; Gorge, 8°; and Tryon, 10°. Ellijay, with its vertical height of 1,760 feet, is the only slope on which a norm greater than 10° was observed in the entire four years. The largest there was 11°, December 9, 1916, as shown in Figure 67, and one of 10° was registered on six dates.

That figure has been prepared to show graphically the monthly variation in the frequency of norms, as well as the average and extreme amounts for the six long slopes, and is comparable with the graph representing inversions (fig. 52).

In including Altapass in the study of the frequency of inversions in connection with Table 13, there is a certain complication in that there was no valley-floor station available on that slope during the period of the research and the temperature readings do not therefore indicate the range of inversion that is shown by the groups having valley floor stations. However, it would seem that the employment of the Altapass slope in Table 22 in connection with the frequency and range of norms would be free from the complications apparent in the study of "Inversions," and this is found to be true, as the degree of norm depends less upon the topography than upon the differences in elevation between the various points under consideration. However, Ellijay, the longest slope, has by no means the largest number of inversions, but ranks in the entire period fourth of the six long slopes.

In Table 22 Altapass is shown to have the largest number of norms of 5° or more, 284; Tryon, with 264; Cane River, 195; Ellijay, 167; Gorge, 119; and Globe, 69. Altapass, with the greatest number, and Globe, with the smallest number, each having the same vertical height between their base and summit stations, 1,000 feet. The largest norm observed on either slope is 8°, while the average is 6° and 5°, respectively. Altapass, situated on the summit of the main chain of the Blue Ridge, has no protection to the north and west in the vicinity, while Globe has the protection to the northwest of Grandfather Mountain, the most massive mountain in the entire North Carolina region. The question of surface area in the immediate vicinity has doubtless an important bearing in the matter of norms. Altapass, on whose slope the largest number of norms occurs, not only has no protection to the north and west, but also has great surface area in the vicinity of the summit; and Tryon, ranking second on the list of the number of norms also has great surface area near the summit, while Cane River, Gorge, and Ellijay have comparatively little area at the summit. Globe, however, which ranks lowest, although having considerable area in the direction of Grandfather Mountain, at the same time has the protection of that vast peak, and the winds from the northwest coming from it are always descending and being warmed mechanically on their arrival at the base station. Doubtless the presence of protecting ranges in the direction from which cold waves come is a factor.

Furthermore, at Altapass the range of temperature considered is between the summit and No. 1, and the fact that the latter station happens to be on a slope may be an additional reason for the large number of norms, and as Tryon No. 1 is located on an ideal valley floor the mountain breeze frequently occurs at night, often being intensified by the movement of the air from the plateau above, and on that account the readings of the base station are at times much higher than those at the summit. Some of the norms included in Table 22, especially for Altapass and Tryon, really occurred on nights of inversion—that is, when the temperature was higher on the intermediate slope—and this fact should partly account for the large number credited to those two slopes. That Altapass and Tryon have a large number of norms is important, and the fact that Ellijay with its longer slope has a much smaller number is equally important, especially when it is considered that all norms of 5° are included in this comparison.

TABLE 22.—*Total monthly and annual number of norms of 5° or more on six long slopes (1913–1916, inclusive).*

Stations.	Jan. a	Jan. b	Jan. c	Jan. d	Feb. a	Feb. b	Feb. c	Feb. d	Mar. a	Mar. b	Mar. c	Mar. d	Apr. a	Apr. b	Apr. c	Apr. d	May. a	May. b	May. c	May. d	June. a	June. b	June. c	June. d
1913.																								
Altapass	[1]4	[1]6	..	..	[1]11	[1]6	..	..	[1]6	[1]6	..	..	[1]9	[1]6	..	..	6	6	6	7	4	6	7	13
Cane River	[1]7	[1]6	..	..	[1]11	[1]6	..	..	[1]7	[1]6	..	..	9	6	8	27	3	6	7	24	2	5	5	10
Ellijay	[1]3	[1]6	..	..	[1]5	[1]6	..	..	[1]3	[1]6	..	..	4	6	7	10	2	5	5	24	0	0	..	..
Globe	3	5	6	4	3	5	5	7	3	5	6	16	2	6	6	5	1	5	5	24	0	0	..	..
Gorge	3	7	7	3	1	5	5	7	2	6	6	27	1	5	5	5	0	0	..	..	0	0	..	..
Tryon	3	5	5	28	11	7	8	5	4	7	9	22	9	6	7	5	4	7	7	7	6	7	9	13
Total, column (a); Average, column (b); Greatest, column (c)	23	6	7	3	42	6	8	5	25	6	9	22	34	6	8	27	16	6	7	7	12	6	9	13
1914.																								
Altapass	11	5	6	22	6	6	7	1	8	6	6	2	7	5	7	27	7	5	6	15	7	5	6	17
Cane River	12	6	10	17	8	7	9	7	[1]7	[1]6	..	..	9	6	8	2	3	6	7	5	3	6	7	16
Ellijay	6	6	7	31	6	6	7	16	7	8	10	9	4	7	9	2	2	6	7	9	1	5	5	18
Globe	1	5	5	4	3	5	5	6	3	5	5	2	1	5	5	9	0	0	..	..	0	0	..	..
Gorge	3	5	5	31	5	6	6	6	6	6	7	20	3	6	7	9	0	0	..	..	4	5	6	19
Tryon	12	6	9	4	6	6	7	15	8	6	8	23	3	6	7	21	0	0	..	..	4	6	7	30
Total, column (a); Average, column (b); Greatest, column (c)	45	6	10	17	34	6	9	7	39	6	10	9	27	6	9	2	12	6	7	9	19	5	7	16
1915.																								
Altapass	7	5	7	15	1	5	5	13	6	6	7	2	8	6	7	12	6	6	6	17	4	5	5	9
Cane River	9	6	8	23	6	6	8	7	9	7	7	1	2	6	7	1	2	6	6	7	1	6	6	25
Ellijay	6	7	9	28	6	7	7	8	8	7	8	8	1	7	7	3	2	5	5	7	4	5	5	29
Globe	2	6	6	22	3	5	6	25	2	6	6	23	0	0	..	..	0	0	..	..	1	5	5	21
Gorge	2	5	5	27	7	5	7	25	5	5	6	17	0	0	..	..	5	5	5	31	2	5	5	4
Tryon	5	5	7	13	6	6	7	16	11	6	8	21	1	6	6	4	6	7	9	30	0	0	..	..
Total, column (a); Average, column (b); Greatest, column (c)	31	6	9	28	29	6	8	7	41	6	8	8	12	6	7	3	21	6	9	30	12	5	6	25
1916.																								
Altapass	6	6	6	23	9	5	6	24	10	7	6	23	5	6	7	10	4	5	6	5	7	5	7	4
Cane River	5	5	6	17	5	6	7	14	8	6	8	8	6	6	9	22	2	7	8	17	2	6	6	7
Ellijay	9	7	10	17	8	7	11	27	9	7	8	8	4	7	8	9	1	6	6	22	2	8	10	7
Globe	3	5	5	7	4	6	7	26	3	6	8	16	5	6	8	22	0	0	..	..	0	0	..	..
Gorge	6	6	6	13	6	6	7	27	5	5	6	27	3	5	5	9	2	5	5	22	1	5	5	16
Tryon	6	6	8	3	10	6	6	26	6	6	7	4	4	5	6	22	1	5	5	22	1	9	9	17
Total, column (a); Average, column (b); Greatest, column (c)	35	6	10	17	42	6	11	27	41	6	9	10	27	6	9	22	10	6	8	17	13	7	10	7

Stations.	July. a	July. b	July. c	July. d	Aug. a	Aug. b	Aug. c	Aug. d	Sept. a	Sept. b	Sept. c	Sept. d	Oct. a	Oct. b	Oct. c	Oct. d	Nov. a	Nov. b	Nov. c	Nov. d	Dec. a	Dec. b	Dec. c	Dec. d	Annual. a	Annual. b	Annual. c	Annual. d
1913.																												
Altapass	5	5	5	5	1	6	6	2	6	6	10	14	11	6	8	15	6	5	7	24	13	6	7	10	82	6	10	Sept. 14.
Cane River	0	0	..	..	1	5	5	21	2	6	6	10	2	6	6	21	2	6	6	10	2	6	7	8	48	6	8	Apr. 27.
Ellijay	0	0	..	..	0	0	..	..	1	6	6	21	2	6	6	20	2	6	6	10	4	6	9	31	26	6	9	Dec. 31.
Globe	0	0	..	..	0	0	..	..	0	0	..	..	0	0	..	..	1	6	6	9	1	5	5	8	14	5	6	Nov. 9.
Gorge	0	0	..	..	1	5	5	13	1	5	5	17	2	5	5	24	3	6	7	9	3	5	5	1	17	5	7	Jan. 3.
Tryon	6	5	6	19	5	5	6	21	2	6	6	14	8	8	11	31	4	8	9	24	6	6	6	27	68	6	10	Oct. 31
Total, column (a); Average, column (b); Greatest, column (c)	11	5	6	19	8	5	6	21	12	6	10	14	25	6	11	31	18	6	9	24	29	6	9	31	255	6	10	Oct. 31.
1914.																												
Altapass	6	6	6	18	1	5	5	30	1	5	5	13	7	5	6	16	11	6	8	16	15	6	7	30	87	5	8	Nov. 16.
Cane River	1	5	5	7	1	5	5	4	3	6	6	13	6	6	9	27	3	6	6	17	9	6	8	31	65	6	10	Jan. 17.
Ellijay	0	0	..	..	0	0	..	..	2	6	6	10	3	6	7	3	4	6	7	20	6	6	9	10	41	6	10	Mar. 9.
Globe	0	0	..	..	0	0	..	..	0	0	..	..	0	0	..	..	2	5	5	20	2	6	6	13	12	5	6	Dec. 13.
Gorge	0	0	..	..	0	0	..	..	4	5	6	13	4	5	5	24	5	6	8	16	5	6	8	26	39	6	8	Dec. 26.
Tryon	5	6	8	25	4	6	6	22	4	5	6	13	3	7	9	12	4	6	6	20	15	6	7	14	68	6	9	Oct. 12.
Total, column (a); Average, column (b); Greatest, column (c)	12	6	8	25	6	6	6	22	14	5	6	13	23	6	9	12	29	6	8	16	52	6	9	10	312	6	10	Mar. 9.
1915.																												
Altapass	3	5	6	3	2	5	5	9	0	0	..	..	1	5	5	24	4	6	7	22	8	5	6	30	50	5	7	Jan. 15.
Cane River	2	6	6	10	2	6	6	13	1	5	5	30	0	0	..	..	5	6	7	15	5	6	7	13	44	6	8	Feb. 7.
Ellijay	0	0	..	..	1	5	5	28	2	5	5	30	2	6	6	7	7	7	10	29	5	8	10	18	44	6	10	Nov. 29.
Globe	0	0	..	..	0	0	..	..	1	5	5	1	1	5	5	8	2	5	5	29	1	5	5	14	13	5	6	Mar. 23.
Gorge	1	5	5	5	1	5	5	28	2	5	5	30	2	6	6	18	0	0	..	..	0	0	..	..	27	5	7	Feb. 25.
Tryon	1	6	6	13	2	6	6	6	1	5	5	5	6	7	9	9	5	7	8	27	10	6	8	13	54	6	9	Oct. 9.
Total, column (a); Average, column (b); Greatest, column (c)	7	6	6	13	8	5	6	13	7	5	5	30	12	6	9	9	23	6	10	29	29	6	10	18	232	6	10	Nov. 29.
1916.																												
Altapass	1	6	6	4	5	6	7	14	5	5	6	16	2	5	5	22	7	6	7	26	4	6	6	1	65	6	7	Nov. 26.
Cane River	2	5	5	30	0	0	..	..	2	6	7	13	3	5	5	21	1	9	9	24	2	6	6	16	38	6	9	Apr. 22.
Ellijay	9	7	10	11	1	6	6	3	2	6	8	29	4	6	7	11	3	9	10	24	4	8	9	22	56	7	11	Feb. 27.
Globe	0	0	..	..	3	6	7	1	2	6	6	29	2	6	6	18	3	7	8	24	5	8	11	22	30	6	8	Dec. 22.
Gorge	1	5	5	10	3	5	6	18	3	6	8	2	2	6	7	18	3	5	5	25	1	6	6	9	36	5	8	Sept. 2.
Tryon	5	6	9	4	12	6	9	2	7	7	9	6	7	6	10	21	8	6	10	25	7	7	9	1	74	6	10	Oct. 21.
Total, column (a); Average, column (b); Greatest, column (c)	18	6	10	11	24	6	9	2	21	6	9	6	20	6	10	21	25	7	11	16	23	7	12	29	299	6	12	Dec. 29.

	Jan. a	Jan. b	Jan. c	Feb. a	Feb. b	Feb. c	Mar. a	Mar. b	Mar. c	Apr. a	Apr. b	Apr. c	May. a	May. b	May. c	June. a	June. b	June. c	July. a	July. b	July. c	Aug. a	Aug. b	Aug. c	Sept. a	Sept. b	Sept. c	Oct. a	Oct. b	Oct. c	Nov. a	Nov. b	Nov. c	Dec. a	Dec. b	Dec. c	Four-year annual. a	Four-year annual. b	Four-year annual. c	Four-year annual. d
1913–1916.																																								
Altapass	28	5	7	27	6	7	30	6	9	29	6	8	23	6	6	22	5	7	15	6	6	9	6	7	12	5	10	21	5	8	28	7	18	40	6	7	284	6	8	Nov. 16.
Cane River	33	6	10	30	6	9	31	6	8	26	6	9	10	6	8	8	6	7	5	5	6	4	5	6	8	6	7	11	6	9	11	7	9	18	6	8	195	6	10	Jan. 17.
Ellijay	24	6	10	25	6	11	27	7	10	13	7	9	7	6	7	7	6	10	9	7	10	2	6	6	7	6	8	11	6	7	16	7	10	19	7	10	167	6	11	Feb. 27.
Globe	9	5	6	13	5	7	11	6	8	8	6	8	1	5	5	1	5	5	0	0	..	3	6	7	3	6	6	3	6	6	8	6	8	9	6	11	69	5	8	Dec. 22.
Gorge	14	6	7	19	6	7	18	6	7	7	5	7	7	5	5	7	5	6	2	5	5	5	5	6	10	5	8	10	6	7	11	6	8	9	6	8	119	5	8	Dec. 26.
Tryon	26	6	9	33	6	8	29	6	9	17	6	7	11	6	9	11	7	9	17	6	9	23	6	9	14	6	9	24	7	11	21	7	10	38	6	9	264	6	10	Oct. 31.
Total, column (a); Average, column (b); Greatest, column (c)	134	6	10	147	6	11	146	6	10	100	6	9	59	6	9	56	6	10	48	6	10	46	6	9	54	6	10	80	6	11	95	7	10	133	6	11	1,098	6	11	Feb. 27, 1916.

[1] Values interpolated.

(a) Number of nights during which a difference of 5° or more occurred between base and summit stations.
(b) Average (degrees) differences between base and summit stations.
(c) Amount (degrees) of greatest norm.
(d) Date of greatest norm.

Naturally the largest number of norms occurs in the coldest and most stormy season of the year (Fig. 67) or when the vapor pressure is least, February having 147, March 146, January 134, and December 133. July and

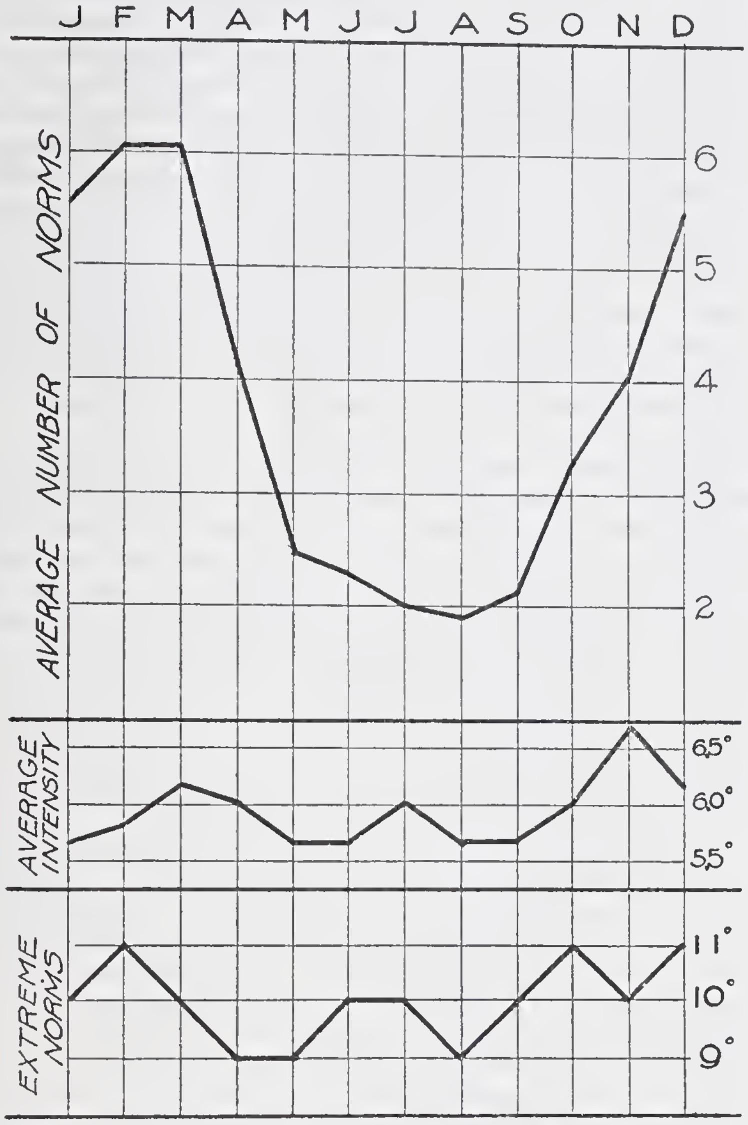

FIG. 67.—Monthly frequency and average and extreme degrees of norm on six long slopes.

August have the least number, 48 and 46, respectively, doubtless because of the lack of storm movement and high humidity. The largest number, 312, occurred in 1914, while the smallest number was 232, in 1915.

While periods of inversion of large amounts often last a week and sometimes even two weeks, as shown by Tables 5 and 7, which give the daily minimum temperatures and variations for Ellijay for May and November, respectively, 1914, norm periods exceeding 5° seldom last more than a few days at a time, even in the winter season; but periods of small norms may continue for prolonged periods, as in January, 1916 (Table 11). Generally speaking, the frequency of inversions is much greater than that of norms. Comparing Table 13, giving the number of inversions of 5° or more for the entire period in North Carolina on the six slopes having a length of 1,000 feet or more, with the number of norms of the same degree in Table 22 we find that the inversions total 3,316, as compared with the total norms, 1098. In other words, inversions occur almost three times as frequently as norms. This is in itself most important.

Of the individual slopes, Altapass is the only one during the research period which has a larger number of norms than inversions, 284 as compared with 173, but this fact is only apparent and not real, as the number of inversions on the Altapass slope is not indicated in any degree in Table 13 because of the absence of a base station there.

Of the other slopes, Tryon has barely twice as many inversions as norms, the percentage there being smaller than on the remaining slopes because of the great mass at the summit at Tryon and the mountain breeze at the base station at night, to both of which conditions reference has been made before.

On the other hand, Gorge has during the period 705 inversions, as compared with 119 norms, and Globe 549 inversions, as compared with 69 norms, the preponderance of inversions at the latter station being the greatest of all.

Individual instances of norms may be noted by a study of the various thermograph traces (figs. 59, 60, 68, and 69). Moreover, Figure 68 illustrates the top freeze or norm condition during the selected period in December, 1916, for Ellijay, as well as the inversion, and shows the vertical distribution of temperature during a period of active weather in December by means of isopleths in the upper portion of the graph and by the superimposed traces of the summit and base stations in the lower part of the graph.

Isopleths showing progressive distribution of temperature at Ellijay during a December period.—The isopleth in

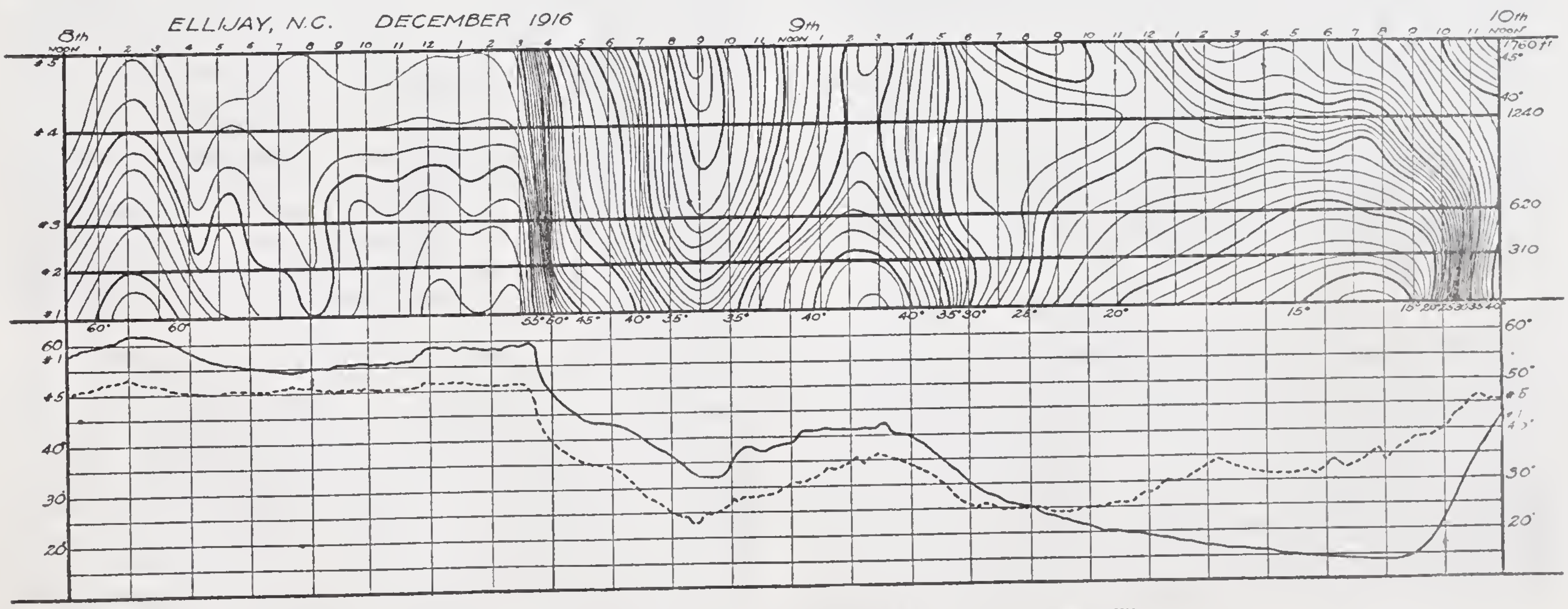

FIG. 68.—Isopleths and thermograph traces, selected period, December, 1916, Ellijay.

Figure 68 shows the distribution of temperature on the 1,760-foot slope at Ellijay during a period of the more active weather conditions, which are typical of the colder season of the year, from noon, December 8, to noon, December 10, 1916. The upper portion of the graph gives the temperature distribution during a warm, cloudy, and rainy period, showing a small decrease in temperature with elevation followed by a sharp cold wave beginning at about 3:30 a. m. of the 9th. The high northerly winds over this region bring cold air to the summits faster than they can drive the warm air out of the valleys below, so that the vertical temperature gradient is much increased and not infrequently superadiabatic during a cold wave. This is well shown during the morning of the 9th and to a lessening degree during the remainder of the daylight hours, the temperature at 8 a. m. of the 9th being 36° at No. 1 and 25° at No. 5. The rate of decrease in temperature between base and summit at this hour, 11° for 1,760 feet, or practically 2° for each 300 feet, is twice the average rate in free air.

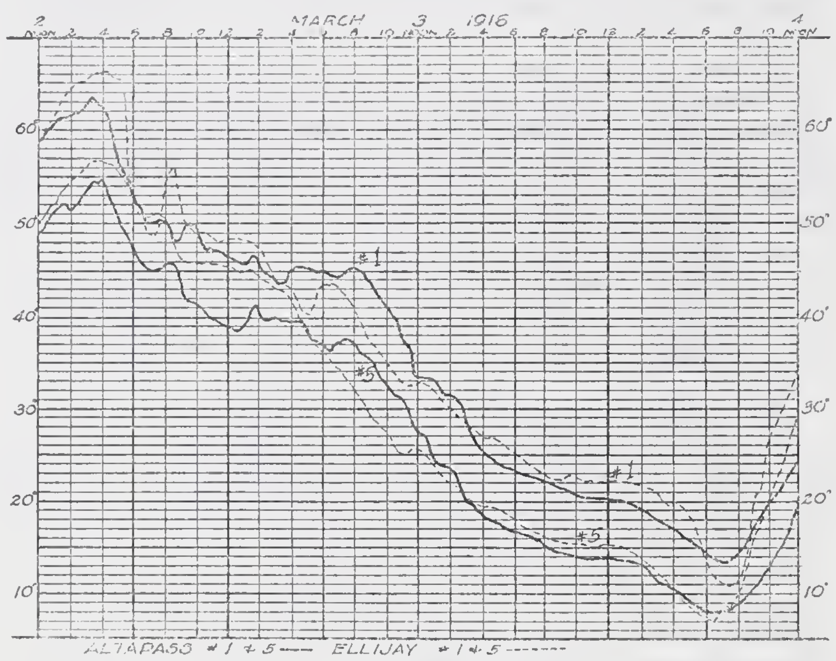

Fig. 69.—Thermograph traces, March 2-4, 1916, stations Nos. 1 and 5, Ellijay.

But with clear weather and diminishing wind velocity, a slow recovery in temperature begins at the summit station at about 9 p. m. of the 9th, with the center of high pressure moving northeastward.

The lower portion of the graph contains thermograph traces for Nos. 1 and 5 during the same period from noon December 8 to noon December 10, 1916, and illustrates graphically the norm conditions on the 9th, gradually changing to those of inversion during the succeeding night and reaching the greatest development by about 8 a. m. of the 10th.

HOUR-DEGREES OF FROST.

In fruit growing the degree to which the temperature falls on a critical night is important, but the duration of the damaging temperature must be given equal consideration. The injury to fruit on two different nights when the temperature falls to 30°, for instance, will vary greatly, provided there is a great difference in the length of time the temperature remains below 32°. In one case the temperature may rise almost immediately after the low point is reached, and freezing temperature may last only an hour or so, while in the other case the recovery from the low point may be very slow, with freezing temperature continuing for several hours.

In order to represent the volume of freezing temperature, so to speak, a numerical value, called "hour-degrees of frost," has been employed in this study. This idea is analogous, broadly speaking, to the "kilowatt-hour" magnitude used in electrical measurements. In other words, the quantity of hour-degrees of frost is the product of the number of hours and degrees below 32°, and this has been found through the use of a planimeter by measuring the area on the thermograph trace sheets between the temperature curves and the 32° line. The symbol, HF°, will be employed here in designating the volume.

In the discussion of the data of Hour-Degrees of Frost reference will be made as far as practicable to the amount and extent of damage to fruit in the mountain region, as noted by the various observers, and for this reason the dates and periods selected will be taken up in chronological order.

The greatest damage to fruit in the region is caused during a top freeze, and particularly is this true when a top freeze follows a period of a week or more during which the temperature has been continuoulsy above normal and the fruit buds have begun to swell or even open. Well-marked examples of this condition occurred March 28 and 29 in the spring of 1913. Immediately preceding this cold spell the temperature throughout the mountain region was considerably above the normal, the week before averaging daily an excess of 10°, with maxima ranging from 65° to 75° at all points in the region, except the more elevated sections.

This warm period ended on March 27 and was followed by a marked change to colder with norms on the first of the two dates in question at all stations except Bryson, the most westerly location, and general inversions on the last date. With the exception of Transon, Wilkesboro, Mount Airy, and Tryon, the damage done by the cold high winds of the 27th–28th and by the freeze of the 28th–29th was general, and the buds of peaches, pears, and plums, and some varieties of apples were so damaged that the yield as a whole was the lowest in many years. At Blowing Rock, Highlands, and Transon the injury was slight as compared with other points, and it is probable that owing to the high elevation of the orchards at these locations, the temperature during the preceding warm spell did not reach a degree sufficiently high to advance the fruit buds to a stage where they were susceptible to great injury by the following cold. However, at these high altitudes damage is very likely to occur later in the season, when the fruit is farther advanced and when orchards at lower elevations are more likely to escape injury. In fact, as late as May 11 and 12 in the same spring killing frosts caused great damage at Transon and Blowing Rock. In the Flat Top orchard in the latter place fruit was killed even to an approximate height of 60 feet on the slopes, and at station No. 3 during this two-day period in May the temperature fell to 23° with 24 HF° on the 11th, and to 29° with 11 HF° on the 12th.

During the two-day period mentioned above the number of HF° at Mount Airy, Wilkesboro, and Tryon was small as compared with those at other stations, although the actual temperatures were below freezing. On the first night with norm conditions the number of HF° was generally greatest at the summit stations and least at the base, while on the second night, with inversion conditions, the reverse was the case. This relation will be found to exist generally during all cold periods. It will, therefore, be seen that, broadly speaking, the higher

levels on a slope experience damage from top freeze or norm conditions, those at the base receive injury from frosts, and the intermediate positions are freer from damage by either freezes or frosts. This is especially the case with long slopes.

During the spring of 1914 there was comparatively little damage to fruit in any section of the mountain region, and the condition of all fruit was considerably above the average. However, at Blowing Rock the apple bloom in the vicinity of No. 3 was light as compared with that in the upper portion of the Flat Top orchard, and it is thought that this condition was a result of the heavy freeze on the valley floor the previous year, May 11–12, 1913, already referred to.

With the exception of a few days in the last week of March, 1914, the weather was abnormally cold, and it is very likely that the freedom of the fruit buds from injury was then due to the fact that they had not been forced by early periods of growing weather such as occurred in the spring of 1913. The only period during the spring of 1914 in which damage could have occurred was that of April 9–10, in which the estimated peach crop at Blantyre was reduced one-third. In this period norm conditions were general on the first day, approaching inversions at most stations on the 10th, with inversions generally on the 11th at all stations.

Combining the total HF° for each of the three dates, the largest number on any slope generally occurred at the higher stations, the more elevated slopes had the greatest number, and of the less elevated slopes, Mount Airy, Wilkesboro, and Tryon, the base stations, in comparison with the respective summits had the greatest number of HF°. This is mainly because the slopes at Mount Airy and Wilkesboro are short and inversion conditions predominate, as the norm frequency depends almost entirely upon the length of slope and not necessarily upon elevation above sea level. At Tryon, however, the slope is considerably longer than at either Wilkesboro or Mount Airy, and the relatively large number of HF° at the base station during this period was due to the lack of a breeze down the valley and the prevailing on-slope winds which brought quantities of warm air to the stations on the slope, while the accumulation of cold air and its cooling by radiation was allowed to continue on the valley floor without interruption, thus permitting the temperature there to fall several degrees below freezing.

During this April period in 1914 the cold stations on the slopes at Gorge and Hendersonville, No. 2 in each case, had the greatest number of HF° on their respective slopes, as did also Mount Airy No. 3, easterly slope, as compared with No. 2, westerly slope, at the same elevation above the base. There was little difference between the two slopes at Asheville, except that at the highest stations, Nos. 3 and 3a, where the number of HF° at No. 3a on the southerly slope was 30 less than at the station on the opposite slope at the same elevation.

In the autumn of 1914 there occurred on November 20 and 22 a notable example of a norm followed by an inversion, while on the 24th and 25th excellent examples of general inversions were recorded, with the temperatures at most of the higher slope and summit stations considerably higher than their respective base stations. The minimum temperatures observed on November 20, 1914, were the lowest noted during the research for so early in the season, and this is borne out by the large number of HF° in all localities, including even Tryon, where the lowest minimum was 11° at No. 4 with a total number of 209 HF°. When severe cold during norms covers the region, the degree of cold depends chiefly upon the elevation and latitude.

Under date of November 22 there was a general decrease in the number of HF° with increase in elevation—a condition typical of inversion nights. At the higher stations on several of the slopes the temperature did not reach the freezing point at all, while at their respective base stations the minima were much below 32°, remaining at that degree for several hours. At Gorge, Hendersonville, and Blantyre, for instance, the contrast between base and summit stations was quite pronounced, the number of HF° being, respectively, 137 and 0, 174 and 0, and 202 and 1. A marked effect of wind direction was noted at both Bryson and Mount Airy in that the HF° at Nos. 2a and 3, respectively, were greater than at the other stations of the same elevation, No. 2 in each case. There is ordinarily little difference between the HF° at Nos. 2 and 3 at Mount Airy, respectively on westerly and easterly slopes, and the southerly slope at Bryson, No. 2a, is not often so much colder than No. 2 on the northerly slope as to cause a difference of 33 HF°, as recorded on November 22. In fact, at Bryson the minimum temperature at No. 2a was only 1° lower than at No. 2, but the temperature at the former station reached freezing an hour before the same degree was recorded at No. 2, and, under the influence of uninterrupted cooling by radiation, fell 5° lower, reaching 27° at 9 p. m. At No. 2 at the same hour the temperature rose to 34° under the influence of light northwest winds, bringing warm air to the slope, while No. 2a, located on the lee side of the knob with reference to northwest winds, apparently did not receive any of this warm air. Toward morning, with diminishing wind, the temperature at both stations reached their respective minima. At Mount Airy a similar condition prevailed in that the westerly winds prevented the temperature from remaining at a low point on the west slope, while on the easterly slope loss through radiation continued practically all night, resulting in low minima.

The two nights of November 24 and 25 were typical of general inversions, and the resulting HF° represent fairly well the temperature conditions experienced on the various slopes. At nearly all locations the greatest number of HF° occurred at the base station, decreasing rapidly with increase in elevation up the slopes to the summit stations, where practically none was recorded.

The spring of 1915, like that of 1914, was generally favorable for fruit growing in the mountain region as far as the meteorological conditions were concerned, although some damage was done by cold winds during March. There was a full crop of peaches, while the yield of apples was very light, as damage from blight occurred in most sections, except at Highlands, where nearly a full crop was reported. At Wilkesboro also there was a good crop of both peaches and apples.

In both the China and the Flat Top orchards at Blowing Rock the apple crop was a complete failure in 1915, owing to an unusually heavy hailstorm on April 23, which knocked off the buds just as they were beginning to swell.

During the period from October 9 to 12, inclusive, 1915, there occurred an example of an early cold spell in the orchard region, with norms general on the 9th and inversions on the 11th and 12th, part of the stations reporting the former and part the latter conditions on the 10th. Tryon did not register a minimum of 32° during this period, except at the top station, No. 4, on the 9th and 10th, when freezing temperature was experienced on each night for one hour.

The spring of 1916 was quite similar to that of 1913, both seasons being unfavorable for fruit growing in the mountain region. There were several periods of warm growing weather in January in both years, followed by much colder weather in February. In fact, the average temperature for January, 1913 and 1916, exceeded that for the respective Februaries by 6.2° and 6.7°. It is this very condition—periods of growing weather in the middle of winter, forcing the fruit buds to a susceptible stage, and followed later in the season or in early spring by cold weather—which kills or damages the buds and seriously affects the raising of fruit at the higher elevations.

As stated before, January, 1916, was unusually warm, the average daily excess in temperature above the normal, as shown by the records at the Asheville Weather Bureau station during the last decade being 17°, with maxima averaging more than 60°. This warmth was followed during the first half of February by temperatures slightly above the normal, with the exception of a few days, so that at the beginning of the second decade the season was several weeks early, and the sudden change to abnormal cold on the 14th practically wiped out the peach crop throughout the region, except at Tryon, by killing the buds which had been brought to a tender condition. The cold continued until the 17th, although all damage done to fruit occurred on the first two nights, when norms prevailed generally. By the 16th inversions appeared, and by the 17th only the colder base stations experienced frost intensity of any importance.

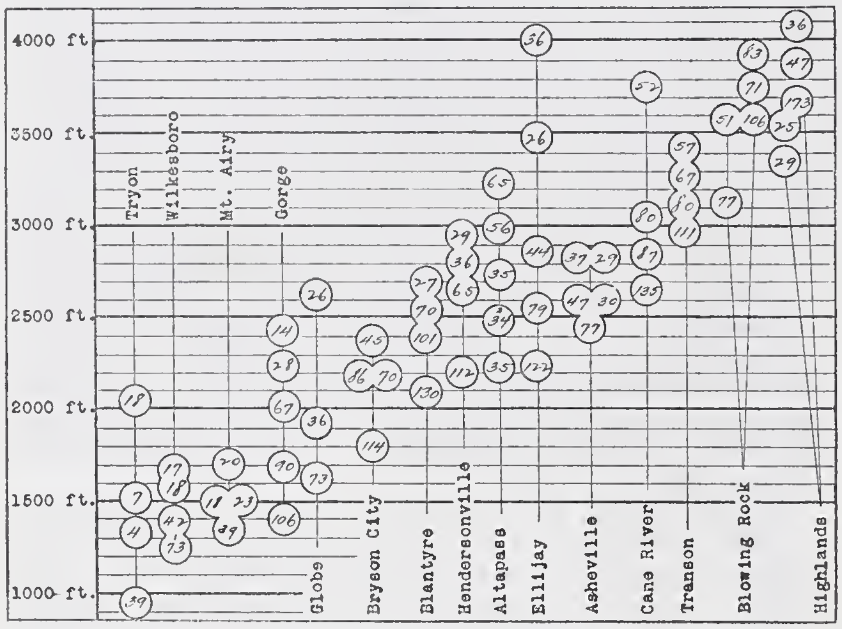

FIG. 70.—Average number of hour-degrees of frost, 10 selected inversions.

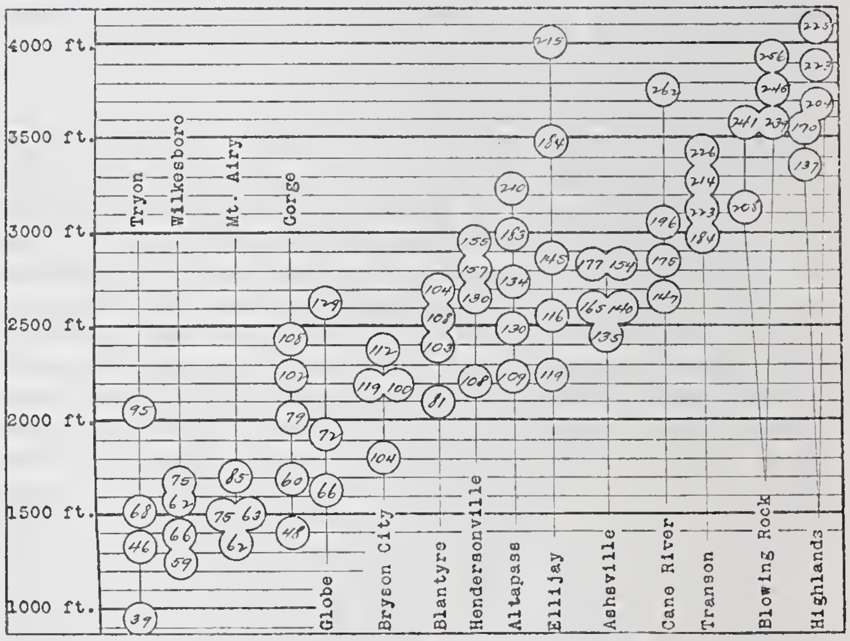

FIG. 71.—Average number hour-degrees of frost, 10 selected norms.

Another cold spell occurred in 1916 from the 15th to the 18th of March and caused further damage to the peach crop by the heavy freeze the first two nights. On the 18th inversions prevailed on all slopes, if we consider No. 1a at Altapass as the true base for that slope, and use for it the HF° value at Gorge No. 1. On this date the HF° at No. 5 Altapass and Gorge No. 1 were 50 and 60, respectively, and taking the whole slope at Altapass from No. 5 to No. 1a, the middle of the thermal belt is seen to be at No. 2.

In the spring of 1916 still another period of cold weather was noted in April, from the 7th to the 10th, inclusive, attended by strong northwest winds and considerable snow at the higher elevations. This may be considered a typical norm period for all stations, as the inversions which occurred on the 10th, the last day, were weak in character and limited in extent. For the period as a whole the frost intensity was therefore greatest at the summit stations, except at points having cold base stations, such as Blantyre and Bryson, where the frost intensity on the 10th was much greater on the valley floor than it was at the summit during the norm conditions.

Reference may here be made to Figures 70, 71, and 72, showing, respectively, the average number of HF° at each station for 10 typical inversions, 10 typical norms, and the average number for the 20 nights of both conditions, the HF° being grouped according to the elevation of the various stations in a manner similar to the graphs discussed under "Inversions and norms (figs. 47, 48, and 49. As the relation of HF° to average minima during these conditions is generally marked, Tables 2 and 2a can be used to advantage in this connection.

There is great variation in the locations on the various slopes where the duration of the minimum temperature is longest or shortest, and this is only natural, as the duration has reference to the actual minima observed at the individual stations, which, of course, vary considerably on any slope. For instance, the minima might be 24° at the base, 28° at the summit, and 31° on the slope midway between, and the length of time would then have reference to these particular figures. While it might be expected that the temperature would remain at its lowest point on the portion of the slope, usually marking the center of the thermal belt, the shortest time, yet when it is considered that this lowest temperature is 31° as compared with 24° and 28° at the base and summit, respectively, it is not strange that the duration is not always shorter than those of 24° and 28°. Nevertheless, geographic variation in the HF° values, representing both the duration and the degree of frost, conform rather closely to the variation in minimum temperature.

Under inversion conditions (fig. 70) the largest number of HF° for the entire region is shown to be 173 at station No. 3 in the small frost pocket in the Waldheim orchard at Highlands, where the lowest absolute minimum and the lowest average minimum were registered, and the smallest number was 4 at station No. 2 on the slope at Tryon, also the point of highest minimum, both absolute and average. Highlands is in the group of the highest altitude and Tryon in the group of lowest altitude above sea level. In every case by far the largest number of

HF° is found to be at the base station, provided such station was located on a valley floor. The figures for Altapass are consistent, as its station No. 1 is just as much a slope station as Nos. 2, 3, and 4, and the increasing number of HF° at the higher levels of the slope is of course due to the great surface area in the vicinity of the summit.

Under norm conditions (fig. 71), the stations of highest altitude have the greatest number of HF°; or at least this holds true for each group, but for the groups as a whole there is some variation. For instance, station No. 4, at Cane River, has the largest number of HF°, 262, with smaller amounts at the summit stations of greater altitude, as Ellijay, Blowing Rock, and Highlands. The smallest number of HF° for all the stations, as shown by Figure 71, is 39 at the base station at Tryon, the station of lowest altitude above sea level. In the individual groups there is in most places a steady increase in HF° from the base to the summit during norms, and Ellijay is the only place where the base station has a larger number of HF° than the station immediately above on the slope.

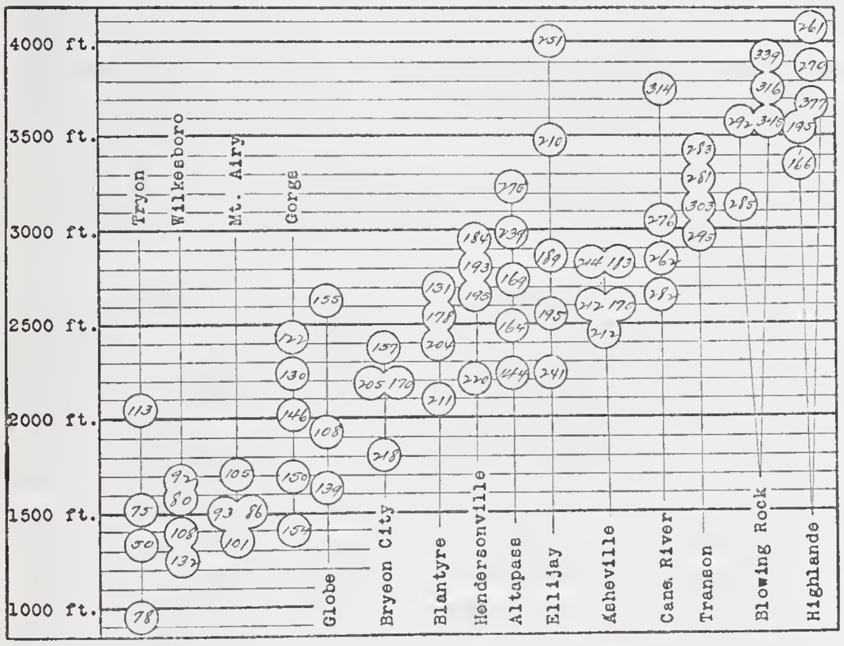

FIG. 72.—Average total number hour-degrees of frost, 10 selected inversions and 10 selected norms.

In Figure 72, portraying the total number of HF° during selected norm and inversion periods combined, generally speaking, the groups having the lowest altitude above sea level have the smallest number and those having the highest altitude the largest number. There is considerable variation in each group, sometimes the greatest number being at the base and sometimes at the summit, but the smallest number is never on the valley floor, but either on the slope or at the summit. For the entire region the smallest number is 50 at station No. 2 on the Tryon slope and the greatest number, 377, at the base station No. 3 at Highlands.

VERDANT ZONES.

Some reference has been made to the subject of verdant zones in the Introduction. Ordinarily, the terms "thermal belt" and "verdant zone" would be considered synonymous; but the latter is the result of special thermal conditions, rather than the thermal conditions themselves.

A thermal belt is the portion of a slope above the valley floor that has relatively high night temperatures, usually reaching the summits of short slopes and often those of long ones as well. It has already been explained how the height of the center of the thermal belt varies on different slopes and on different nights of inversion, depending upon topography and various metorological factors.

The verdant zone may be designated as the portion of a slope in the spring and fall where the foliage remains fresh and green, having been untouched by frost or freezing temperature, while the foliage on other portions of the slope lower down and sometimes higher up has suffered damage. A verdant zone has been considered by many writers as a belt 400 or 500 feet in width a variable distance above the valley floor; but such a zone, while having a lower limit on a slope, may actually extend to the summit, the latter being its upper limit.

A verdant zone may develop on a long slope on a single night of inversion when the temperature falls to freezing or below in the upper as well as the lower levels, leaving a neutral zone untouched, and this is characteristic of a slope having great area at the summit, such as Tryon and Altapass. It may form in the upper levels on a night of inversion when frost occurs in the lower levels with

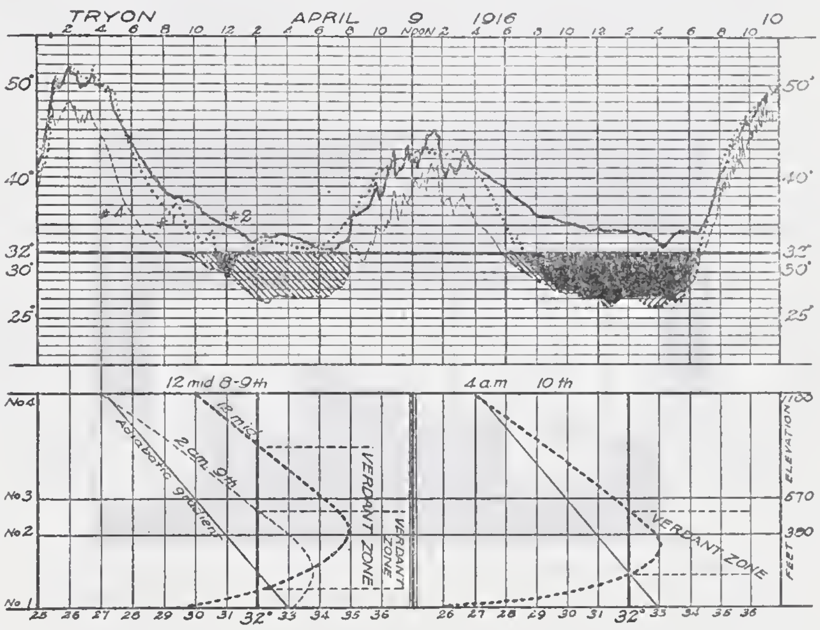

FIG. 73.—Thermograph traces and vertical temperature gradients, April 8-10, 1916, stations Nos. 1, 2, and 4, Tryon.

the thermal belt above reaching to the summit, or it may form in the lower levels during a top-freeze condition, or it may be the result of a combination of inversion and top-freeze conditions over a period of two or more nights. It can be readily understood that on short slopes norms can not be considered a factor, as the temperature varies very little there from the summit downward, usually no more than a degree or two, and if freezing occurs at the summit it is quite likely to prevail over the entire slope down to the valley floor.

The Tryon slope seems to be more favorable than any other for the formation of a verdant zone, because the slope is fairly long, it has no opposing slope and therefore the belt of highest temperature is low, and the area at the summit is great, resulting in relatively low temperature in the higher levels.

The best example of verdant zone conditions on a single night at Tryon duting the four years' record was observed April 9–10, 1915, when the temperature at No. 2 was from 1° to 3° above freezing and the temperature at both Nos. 1 and 4 ranged between 26° and 28°, as shown in Figure 73, the black portions in the upper part of the graph illustrating the length of time

freezing temperature prevailed on the slope above and below the verdant zone. Figure 73 (lower part of graph) also shows the vertical temperature gradient at 4 a. m. on the 9th, as well as at midnight of the 9th–10th, the portion of the curve on each night to the right of 32° line representing the verdant zone and that portion of the slope where the minimum during these nights did not fall below 32°. At midnight on the night of the 8th–9th, the verdant zone was unusually wide, the lower limit reaching almost down to No. 1 and the upper limit a little over halfway between Nos. 3 and 4—probably a distance of 750 feet. At 2 a. m. the zone was reduced to its normal width by the lowering of the temperature at all stations except No. 1, the reading at No. 2, however, still remaining above freezing.

Figure 73 illustrates the temperature distribution on the slope at Tryon during the formation of a verdant zone. The portions of the thermograph traces falling below the freezing point have been shaded. The lower portion of the graph shows the vertical temperature gradients during the critical hours on each night, also the approximate width of the resulting verdant zones.

There were several other instances at Tryon in the spring and fall during the four-year period of the research when the conditions were favorable for the formation of a verdant zone.

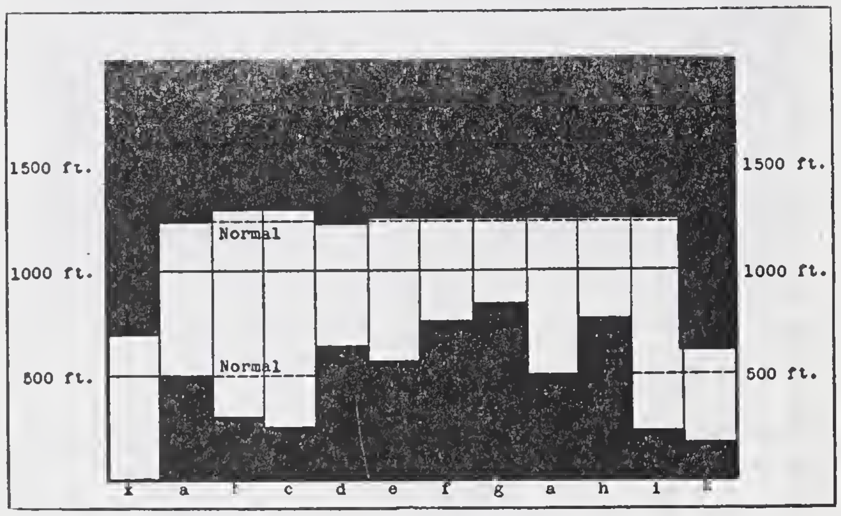

FIG. 74.—Possible variation in limits of verdant zone on mountain slopes.

On the night of October 21, 1913, during an inversion the temperature was freezing or below at all stations on the slope down to No. 2, and practically the same condition occurred on October 31 and November 1 following, and it was not until 20 days thereafter that there was a general freeze.

In the spring of 1914, on April 10, a freeze occurred at station No. 4 and frost at No. 1, with relatively high temperature on the slope at stations Nos. 2 and 3, thus favoring the formation of a wider verdant zone than in the preceding autumn.

In the autumn of 1914 conditions were favorable for the formation of a verdant zone on the night of October 28, much the same as in the autumn of 1913.

In the autumn of 1915 a top freeze occurred at Tryon on October 9 and 10, at No. 4, but it was not until November 4 that the temperature fell to the frost point on the valley floor at No. 1. Later, on November 16, the temperature fell to freezing on the slope from summit down to No. 3, and a general freeze did not occur until November 30. As a consequence a wide verdant zone apparently formed in the early portion of the autumn period, but it was considerably narrowed later.

In the spring of 1916, after a month of growing weather, freezing temperature occurred on April 9 and 10 from summit down to No. 3, and frost simultaneously at No. 1 in the valley floor, thus favoring the formation of a verdant zone around station No. 2.

Generally speaking, there is a tendency toward the formation of a verdant zone on the Tryon slope in the spring and autumn, 300 or 400 feet in width, with the lower limit about 300 feet above the valley floor. However, the limits of this zone are seldom clearly defined, as they vary irregularly on the slope, just as the temperature varies.

The line of demarcation on any slope between verdant and frosted foliage is not clearly cut, although such claims have often been made. It has been stated even that photographs of certain slopes would show this phenomenon distinctly, but it must be conceded that during the period of the research it was not possible to find any slope so well marked, there usually being a gradual merging of the green and frosted foliage.

It has been pointed out previously, especially under the discussion of "Average minimum temperature and inversion" that the minima on any slope vary decidedly with topography and surrounding vegetation, depending on the relative steepness of the slope, proximity to neighboring slopes and timber, the relative area at the summit, the character of the valley floor, and the extent and density of the soil cover, so that at different points of the same elevation on any slope there is often great differences in minimum temperature, and consequently the line between safety and injury is sure to be more or less ragged.

Figure 74 may represent the limits of a verdant zone possible on mountain slopes having great variation in topography and vegetation. Here the term "verdant zone" is used in the larger sense and includes all cases where a portion of the slope, whether large or small, high or low, is untouched by frost or freezing temperature. The relative length and position of the white columns indicate roughly the position and width of verdant zones under varying conditions of topography and weather.

x represents a zone on any long slope forming after a top freeze when a temperature of 32° was not felt below the height of 700 feet. The other lettered divisions indicate conditions resulting from inversions, or inversions and norms combined: *a*, an average condition with moderate slope and moderate vegetation; *b*, a steep slope at "*c*," widening still further because of increasing grade and bare vegetation; at *d*, because of change to gentle slope with dense vegetation, the lower limit of the belt rises and it falls again at *e* with decreasing vegetation; *f*, in a cove with moderate vegetation and less opportunity for interchange with the warm free air, the lower limit again rises and the zone narrows still further at *g*, which marks the location of a sink or frost pocket, with dense vegetation. It then falls to the limits marked by *a*, a moderate slope with moderate vegetation and at *h* is apparent the effect of opposing slopes in close proximity in the narrowing of the belt, while at the point *i*, where there is no opposing slope and small area at the summit, there is a widening of the belt; and, finally, at *k*, with no opposing slope but great area near the summit, the belt narrows again, the latter conforming to the conditions found at Tryon.

It may be said that the conditions portrayed are purely ideal and could not actually be found on any single slope, and this is true. But the variation is not beyond the realm of possibility in a series of slopes, and there might even be additional variations.

Rise in temperature at summit stations earlier than on the valley floor.—The statement is sometimes made by meteorologists, in their studies of mountain and valley conditions, that the temperature at the summit usually rises before that at the base. Perhaps the observations [7] of Prof. McLeod, of McGill University, were the first made in America along this line, embracing a study of the rises in temperature at the base and summit of Mount Royal, Montreal. Of course the diurnal rise naturally occurs earlier in the morning at the summit than at the base, as the sun strikes the higher points first, but it is not with this diurnal change that we have to do in this discussion. McLeod concluded that it was possible to make temperature forecasts 24 hours in advance at Montreal by noting the changes at the summit of Mount Royal, and he claimed a verification of 78 per cent by this means. The summit of Mount Royal is 620 feet above its base and 800 feet above sea level.

Clayton [8] made some studies along the same line at Blue Hill observatory in Massachusetts several years ago and found variations much the same as those observed by McLeod. Blue Hill has an altitude of 640 feet above sea level, the summit being 590 feet above the valley floor.

Church and Fergusson in their recent studies [9] of temperature conditions on Mount Rose, Nevada, at a much greater elevation, did not find such a variation, and they concluded that Mount Rose was not favorably situated for the occurrence of this phenomenon.

The studies in this research in the North Carolina mountain region, moreover, did not show results similar to those obtained by McLeod and Clayton. In fact, the observations provided no data upon which such temperature forecasts 24 hours in advance could be based. As a rule, the temperature rose one or two or three hours earlier at the summit than at the base, sometimes even rising at the higher levels when it was falling on the valley floor; but rarely was the rise at the summit levels 24 hours in advance of the rise at the base.

In the study of the North Carolina data it is found that the temperature rarely rises at the summit, even where the peaks are isolated, more than 10 hours earlier than on the valley floors, and the average does not exceed four hours. Of course, Mount Royal and Blue Hill are more isolated than the mountain peaks of North Carolina, and this might be considered an additional reason for the early rises, although the elevation of these northern peaks is relatively slight. Possibly the more active wind movement generally in the northern sections is also a factor.

The temperature changes in the higher levels of the Carolina mountain region certainly furnish no basis for the making of temperature forecasts, as found by McLeod and Clayton, and the results are in agreement with those obtained by Church and Fergusson for Mount Rose. Apparently the conclusions of McLeod and Clayton have been accepted by meteorologists, but it is thought that their data should now be more completely examined and verified in view of the more recent studies on the subject.

Many instances have been noted in this research of rises in temperature several hours earlier at the summit than on the valley floor and some instances even when the temperature was still falling on the floor. While such rises, although sometimes slight, have been noted on all slopes, those of large range are only observed on isolated knobs so located as to be free from obstructions in the shape of high elevations to the south and east. Thus Cane River stands out as the most prominent of the points in this research showing the early rises at its summit. Slopes like Altapass and Tryon, which have great area near their summits, and Ellijay, to the southeast of which lies the Highlands Plateau, show these rises in a less degree.

Such rises in temperature result in unusual inversions and these occur in connection with the Intermediate and the Cyclonic Types of inversion. In the Cyclonic Type the early temperature rise at the summit is primarily due to rather fresh southerly or southeasterly winds, which have developed in the advance of the approaching LOW before this air movement has started at the base, surface friction retarding the free movement of the air at the lower levels. In the Intermediate or Recovery Type, as the high pressure begins to pass to the eastward from the region the stations at the higher levels feel the rise in temperature first under the influence of light south to east winds, the hills preventing the cold air in the lower levels from draining away.

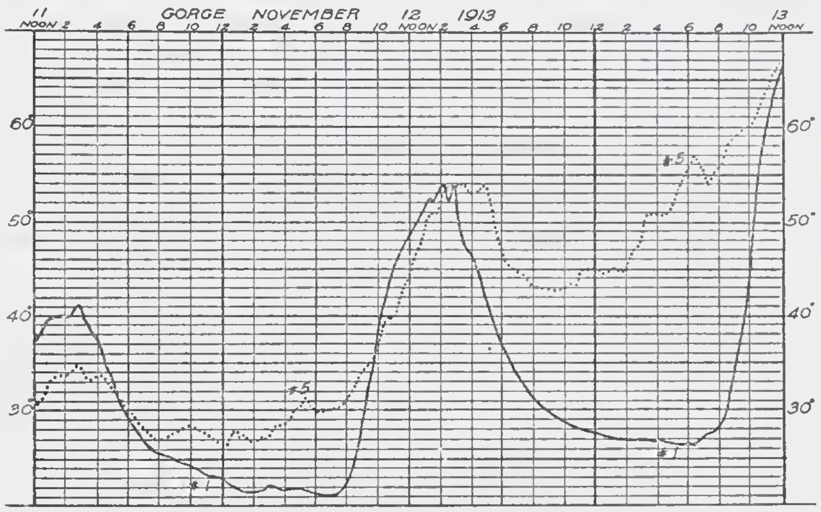

FIG. 75.—Thermograph traces, November 12–13, 1913, stations Nos. 1 and 5, Gorge.

Examples of both types are numerous, but limited space permits but three illustrations, those of Cane River, January 27–28, 1914 (fig. 58), and December 19–23, 1916 (fig. 59), both of which have already been referred to, and Gorge, November 11–13, 1913 (fig. 75)

Figure 59 includes the state of weather and the direction and velocity of the wind as shown by the records at the regular Weather Bureau station at Asheville, which is located only about 25 miles distant from Cane River. It illustrates two sets of conditions attending the early warming up of the summit station; the Cyclonic Type on the 19th–20th, when warm southeast winds were brought to the summit by the development of a LOW to the southwest; and the Intermediate Type, on the 22d–23d, when the rise in temperature following a cold wave began at the summit first without the immediate influence of an approaching LOW. The effect of wind direction and velocity, as well as that of state of weather, is apparent in the comparison of the Asheville wind record with these temperature traces. On the morning of the 18th, a LOW moved rapidly over the region toward the northeast, this condition causing rapid rises in temperature during the afternoon and night. On the 19th the influence of a LOW approaching from the northwest began to be felt at the summit station, while on the 20th the temperature rose generally, the LOW remaining over the region and the temperature being high throughout the

[7] Transactions of the Royal Society of Canada, series 1904–1909.
[8] Clayton, H. H., Blue Hill Observatory Bulletins, No. 1, 1899, and No. 1, 1900.
[9] Bul. 83, Technical University of Nevada Agricultural Experiment Station, 1915.

21st; but on the morning of the 22d the LOW moved away closely followed by a HIGH which had already caused 24-hour temperature falls of 20° to 30° in the adjoining States to the west. The approach of this cold wave gave rapid temperature falls at Cane River, especially at the lower stations, but by the late afternoon the recovery had begun at the top station, about 14 hours ahead of the rise at the base station. One of the outstanding features shown in Figure 59 is the almost steady rise in temperature at the summit station from about 10 p. m., December 19, to noon, December 21, from a minimum of 18° to a maximum of 51°, while during that period there were two distinct and separate falls at the base station to 2° at 5 a. m., December 20, and to 31° at 7 a. m., December 21, with an intervening rise to a maximum of 44°. It seems remarkable that such a pronounced variation in temperature could persist for so long a period of time within such a small radius, the vertical height of this slope being only 1,100 feet. The wind direction during practically the entire period was from the south and southeast, with varying force, light and gentle during some hours and moderate to fresh in others, indicative of unstable conditions.

The large inversion of 31° at the summit of the Gorge slope, 1,000 feet above the base station, November 12–13, 1913 (fig. 75), is the greatest of all observed in the entire research, but an inversion almost as great, 30°, occurred at Cane River January 28, 1914 (fig. 58). In the latter instance the temperature did not begin to rise at the base station until 13 hours after it had begun to rise at the summit. Both are examples of the intermediate type of inversion.

These graphs, illustrating the early rise in temperature at the summit as compared with the base, are supplemented by Table 23, giving for Cane River, Gorge, Globe, and Ellijay, with their summits ranging from 1,000 to 1,760 feet above the floors, data in tabular form which may be considered as representative of extreme instances of the phenomenon where the temperature was rising at the summit at the time it was falling at the base. Examples could also be included where the temperature was not falling at the base were space available for the purpose.

According to Table 23, these rises are much more frequent at Cane River summit than on any of the others, and the rise there begins relatively much earlier, doubtless because of the comparatively isolated position of its summit. Once the rise at Cane River summit began 14 hours in advance of that at the base, and at another time 13 hours in advance; but these are the greatest observed. Ellijay, the most elevated and showing one rise 12 hours in advance, comes next in order. The latter point does not have the same frequency or range as Cane River, probably because of its location in the midst of mountains of equal or greater height and because the Highlands plateau of equal elevation, with Mount Satulah and Whiteside Mountain towering above, lies to the south and southeast directly in the path of these warm winds. Gorge, next in order, has its summit station on an isolated peak, but other mountains in all directions, even higher, are not far distant. The table includes in its list instances of the largest inversions noted during the research, and it may be seen, by comparing columns a and b that the temperature in every case was falling decidedly on the floor while rising at the summit, and the table further shows (column c) that even in these extreme instances the rise at the summit, on the average, began less than nine hours earlier than on the floor.

TABLE 23.—*Most pronounced rises in temperature at selected summit stations at the time falling at the base.*

Station.	Date.	a	b	e
Cane River, No. 4	Nov. 6-7, 1913	19	5	6
Ellijay, No. 4 [1]	Nov. 11-12, 1913	21	12	12
Gorge, No. 5	Nov. 12-13, 1913	31	14	9
Globe, No. 3	do	25	9	8
Cane River, No. 4	Jan. 27-28, 1914	30	14	13
Do	Feb. 2-3, 1914	17	8	8
Globe, No. 3	Feb. 3-4, 1914	13	5	4
Gorge No. 5	do	17	3	7
Ellijay, No. 5	Feb. 16-17, 1914	12	10	8
Do	Mar. 2-3, 1914	10	7	9
Cane River, No. 4	Dec. 6-7, 1915	19	14	10
Do	Jan. 3-4, 1916	21	7	8
Do	Dec. 6-7, 1916	22	7	8
Do	Jan. 9-10, 1916	20	8	8
Do	Dec. 19-20, 1916	24	4	7
Do	Dec. 22-23, 1916	22	12	14

[1] No. 5 at Ellijay not in operation; No. 4 located 1,240 feet above base station.

(a) Greatest difference at any hour (degrees) between base and summit stations.
(b) Amount of rise (degrees) at summit station from sunset to sunrise.
(e) Number of hours temperature rose at summit station before rise began at base station.

Elevations of summit stations above respective base stations: Cane River No. 4, 1,100 feet; Ellijay No. 5, 1,760 feet; Gorge No. 5, 1,040 feet; Globe No. 3, 1,000 feet.

DEW POINT AND ENSUING MINIMUM TEMPERATURE.

No study of minimum temperatures in a field research seems to be complete without a comparison of the evening dew point and the ensuing minimum. It has long been supposed that a relation exists between the dew point and the minimum and that the temperature would not fall any night lower than the dew point, so that, if the point of condensation were higher than 32°, frost should not be expected, because the dew point having been reached, latent heat would be given off in the process of condensation and a further fall in temperature prevented. Moreover, the loss of heat by radiation from the ground is more rapid through dry air than through moist air, and as a consequence when the humidity is high in the evening the temperature the following night is not likely to fall to a low point before morning, while if the humidity is low the temperature will fall considerably. This much we know, of course, and due allowance must be made for the vapor pressure in estimating the ensuing minimum temperature. Attempts have been made to determine with some exactness, through the use of formulas, the point which the minimum will reach. Those prepared by Prof. J. Warren Smith and Charles A. Donnel, of the U. S. Weather Bureau, applicable to a flat or rolling country without great differences in elevation, have received considerable attention.[10]

However, formulas have not proved of any material assistance in determining the ensuing minima to the leader of this project in the special regions in which he has conducted field work. In the research in the Wisconsin cranberry marshes [11] he found that the reading of the dew point in itself did not indicate even approximately the point to which the minimum would fall. The minimum temperature for the seasons of 1906 and 1907 in one section of a bog at Mather, Wis., averaged, respectively, 8.2° and 7.6° lower than the dew point readings of the previous evening at 6 o'clock. On several nights the temperature fell 20° below the dew-point, and on one night it was even 28° lower in spite of the fact that the relative humidity on the bog early the previous evening was as high as 94 per cent. The humidity in a cranberry bog region is naturally high, but it is probable that a short distance above it is much lower. Often the

[10] Smith J. Warren, in Predicting Minimum Temperatures, MONTHLY WEATHER REVIEW, SUPPLEMENT 16.
[11] Bulletin T, Weather Bureau, 1910, by Henry J. Cox.

blanket of fog overlying a bog does not reach higher than 30 or 40 feet, the humidity above it, doubtless, being comparatively low, and thus rapid loss of heat is possible by radiation through the air, and the temperature in the levels below is reduced to a critical point.

As explained in previous pages in the description of stations employed in the North Carolina research, the home station in each group was supplied with a sling psychrometer in addition to the regular equipment, and for purposes of convenience this station was nearest to the residence of the observer, regardless of whether its shelter was on the valley floor, the slope, or the summit. The home stations are slope stations at Altapass, Ellijay, Highlands, and Tryon; valley-floor stations at Asheville, Blantyre, Bryson, Cane River, Globe, Gorge, Mount Airy, and Transou; and summit stations at Blowing Rock, Hendersonville, and Wilkesboro. There is considerable similarity in the exposure of the slope stations, but there is a wide variation in the character of the conditions at the valley-floor stations, and those can hardly be considered comparable one with another. For instance, Asheville, which is located in a cut between two slopes, is itself on an incline along Bull Creek, while the base stations at Gorge and Bryson, although on true valley floors, have environment much different.

Wet-bulb readings were made regularly at sunset, but there was naturally great variation in the results because of the different positions of the home stations at each place. There were individual instances where the minimum temperatures on the slope were 20° to 30° higher than the previous evening dew point, while on the valley floors the minima were correspondingly low. For instance, at Tryon at No. 2, the home station on the slope, the dew point at sunset May 3, 1913, was 33°, and the minimum at the same station during the night was 67°; again, on the evening of April 4, the dew point at Bryson No. 1, the home station on the valley floor, was 67°, the minimum during the night reaching the low point of 35°. In one case the minimum exceeds the previous evening dew point by 34°, and in the other case the dew point exceeds the minimum by 32°.

Dew-point values have been computed from the wet-bulb readings made at sunset for the year 1914, and the average depression of the minimum temperature below the previous evening dew point at each place is shown by months in figure 76, illustrating (*a*) the average monthly variation for all 15 home stations combined; (*b*) for the home stations on slopes, and (*c*) for the home stations on valley floors. The home stations at Blowing Rock, Hendersonville, Highlands, and Wilkesboro, with environments so different from the other stations on slopes and valley floors, have not been included in the comparison shown in this figure by the curves (*b*) and (*c*).

The minimum temperature for all the home stations regardless of location averages below the previous evening dew point in all months except May, curve (*a*), this being the month when inversions are found with the greatest frequency, with the possible exception of November. The average difference between the evening dew point and the ensuing minimum reaches its maximum in May, with secondary maxima in November and January, and minima of practically the same amount in February, August, and September. In February inversions are infrequent, although of large range, while August and September have rather frequent inversions, but of small range.

The curve (*b*), showing the variation at the home slope stations at Altapass, Ellijay, and Tryon, has its maximum in May, with secondary maxima in January and November, the latter month ranking next to May. There are also three minima, August, December, and February, named in order of their respective values. This curve accentuates the effect of conditions attending large inversions in May and November, on the one hand, and those with small inversions in August, on the other. While on the slope the excess in minimum temperature over the previous evening dew point averages more than 8° in May, the depression below the dew point in August is more than 2°, the average variation in this series being 10.6°.

As shown by the curve (*b*), the minima on the slope seem to be much higher than the previous evening dew point, especially in the spring, as compared with the curve (*c*), based upon the differences for the home valley-floor stations. Curve (*c*) conforms roughly with that showing the variation for all the stations combined, (*a*), with maxima of about the same value in January, April, and December, and with a minimum in September and a secondary minimum in February. However, all these

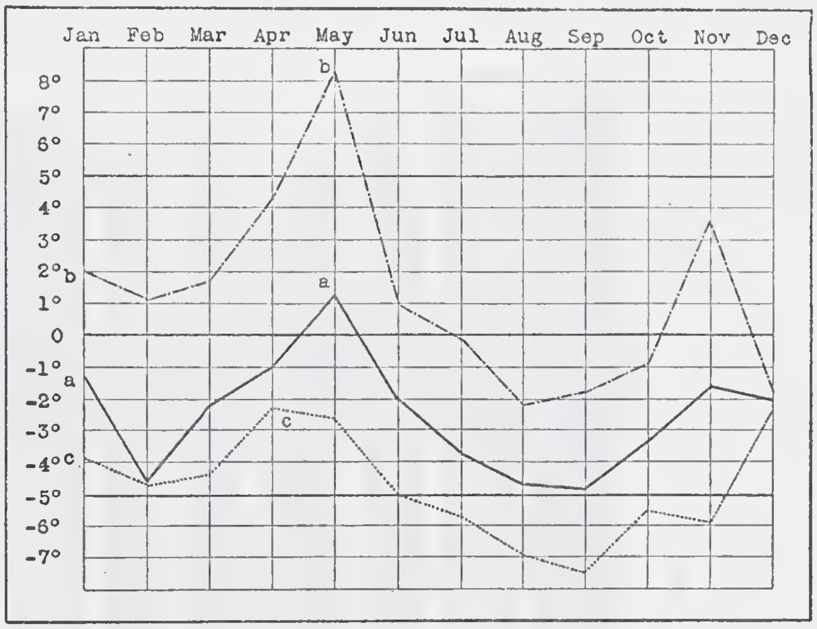

FIG. 76.—Average monthly difference between evening dew point and ensuing minimum temperature.

averages at the base stations show the minimum below the dew point with differences ranging from 2.6° in April to 7.5° in September, there not being a single month when ensuing minimum averages above the previous evening dew point.

Notwithstanding the difference in exposure between individual home stations, there seems to be considerable similarity in the relations existing between the minimum and the dew point at the slope stations, on the one hand, and at the valley floor stations. on the other hand, as shown by curves (*b*) and (*c*).

The above results are in harmony with the thermal conditions as understood in mountain regions. At sunset, the time when the dew-point readings are taken, the temperature along the slope is fairly uniform from the summit to the base, and naturally the ensuing minima are relatively low on the valley floors and high on the slopes in the midst of the thermal belts. These variations, of course, are exceedingly large on individual nights, especially during inversions, and it should be apparent that there would be great difficulty in determining through the use of formulas with any refinement the ensuing minimum temperature in this mountain region.

LENGTH OF GROWING SEASON.

The length of the growing season is usually determined on the basis of the length of time between the last freeziug temperature in the spring and the first freezing temperature in autumn, but sometimes also from the duration of the mean temperature of 42.8° or above. So far as the first plan is concerned, it is generally considered that conditions are favorable for plant growth during any period when the minimum temperature does not fall below 32°, and the second plan is, in fact, based upon the first, and under it the temperature conditions would be much the same, provided the daily range in temperature at the place under consideration averages about 21° or 22°. Thus, if the minimum temperature were 32° and the maximum 53.6°, the mean would be 42.8°. However, there is great variation in the range in temperature, in some parts of the country the range in clear weather exceeding 30°, 40°, and even 50°, while in other parts the average range is hardly more than 10°. In the North Carolina mountain region the daily range varies considerably, but the mean for all the research stations for the four years is 21.3°, so that a minimum of 32° would, on the average, closely represent a mean temperature of 42.8°.

The last and first occurrences of freezing temperature are taken as the limits of the growing season in this review of the situation in the North Carolina mountain region. Data based upon the occurrences of actual frost are not used, because, while hoar frost is frequently observed on the valley floors, it is seldom seen on the slopes except on benches and in coves. There is, moreover, no instrumental record of frost possible. Therefore, a season based upon the occurrences of actual freezing temperature is preferred, simply because minimum temperature data are available at every station employed in the research.

The average of the growing season for the four years of the research does not, of course, represent the normal, as the period is entirely too short, nevertheless it is important that it be stated. The summary of these conditions appear in Table 24, the latest date of freezing temperature in the spring, the earliest date of freezing temperature in autumn, and the four-year average of these dates; also the earliest date of the occurrence of the last 32° in the spring and the latest occurrence of the first 32° in autumn, together with the length in days of the longest and shortest growing seasons, as well as the average length of the growing season for the period of observations. It can readily be seen that there is a great variation in the periods, depending largely upon altitude, the more elevated groups having much shorter seasons than those nearer sea level. The valley-floor stations have the shortest seasons of their respective groups where valley-floor stations exist, and the longest periods usually occur on the slopes, but in some instances at the summit.

It will be noted by examining Table 34 that often the earliest or latest occurrences are given at many points on the same date, and this can be understood when it is considered that the specified dates do not indicate any temperature more definite than the reading of 32°, while, as a matter of fact, the temperatures at some points on the dates in question were several degrees lower, and when later occurrences of freezing temperatures did not occur at any point in a certain season on the given slope, stations having normally a lower temperature appear in the table as having just as long a growing season.

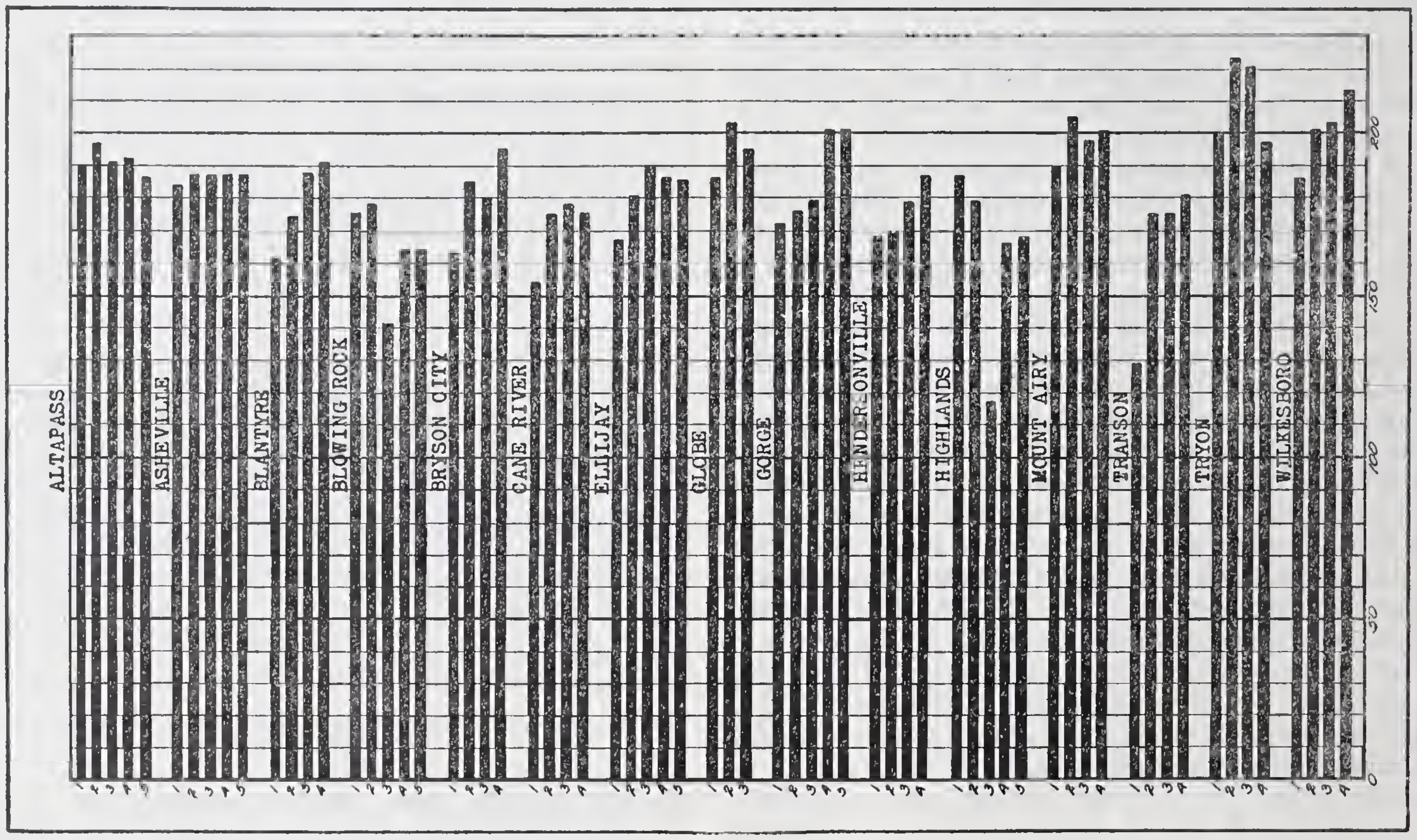

FIG. 77.—Length of growing season.

Figure 77 graphically illustrates the lengths of the growing season by the heavy black lines, and in Figure 78 these periods are shown by groups and elevations. Taking the groups as whole (fig. 78) the most elevated, the Flat Top orchard at Blowing Rock and the Waldheim orchard at Highlands, have naturally the shortest growing seasons, and Tryon, the group nearest sea level, the longest growing season, the extremes ranging from an average of 117 days at Highlands No. 3 in the frost pocket to 223 days at Tryon No. 2 in the center of the thermal belt, with a difference in elevation of 2,345 feet.

Of the individual groups, station No. 1, where located on a valley floor, has in every instance the shortest season except at Tryon. There the season is slightly shorter at the summit, 197 days as compared with 200 at the

base station, and this is due to the cooling effect of the great mass near the summit and the influence of the mountain breeze on the floor, which often raises the temperature at No. 1 during nights of inversion. At Altapass, also, the shortest season is at the summit, because of the surrounding great area, but here we have no valley-floor station for comparison, as No. 1 is located on the slope. In the Satulah orchard at Highlands, where stations Nos. 1 and 2 are, No. 1 has a longer season than No. 2 by eight days. However, both are located on a slope directly under Mount Satulah, and the more elevated station naturally has the shorter growing season. These are the only lowest level stations in the various groups that do not have the shorter seasons.

The stations on the short slopes having the longest seasons are almost invariably found at the summit, as at Wilkesboro, Bryson, Blantyre, Hendersonville, and Transon, including, of course, the Waldheim orchard at Highlands. Mount Airy and Asheville seem to be the only exceptions in this respect. At the summit of Mount Airy the season is four days shorter than at No. 2 on the west slope and but three days longer than at No. 3 at the same height as No. 2 on the east slope, while at Asheville the variation in the length of the season at all five stations in the group is very small, the range being only three days. In fact, this is the smallest difference noted in any of the groups. The largest range is in the Waldheim group at Highlands, from 117 days at No. 3 to 168 days at No. 5, 400 feet above, No. 1 in the Satulah orchard at the same place averaging 187 days. Here we have within the small radius between the base stations in the two orchards a difference in the growing season of 70 days, and this is principally because of the low minimum temperatures at No. 3, so often referred to as a frost pocket.

Gorge is the only long slope having a vertical height of 1,000 feet or more on which the longest season is found at the summit, or at least close to it, both stations Nos. 4 and 5 having the same number of growing days, 201. Ellijay, having by far the longest slope, 1,760 feet in vertical height, has its longest season, 190 days, at station No. 3, the figures there shading off in both directions toward the base and the summit, with 167 and 185 days, respectively. The period at the summit, 185 days, seems unusually long considering its elevation, 4,000 feet, and this is doubtless because of the small surface area at the upper elevation, the temperature there partaking largely of the free air. This period is in contrast with the shorter period, 164 days, at the No. 5 station at Blowing Rock, located at about the same elevation above sea-level, but where the surrounding surface area is great.

These figures show the decided effects of inversions in that the shortest season is most always found on the valley floor, actual freezing temperature being more prevalent there than at the higher levels. At the same time effect of norm conditions is apparent in the fact that the longest season is at the summit of no long slope, except at Gorge, and even there the season at the summit is no longer than at station No. 4, the one next below on the slope.

Now, viewing the length of the season for the various stations by elevation only, as shown in Figure 78, we find again that of the stations having approximately the same elevation the valley-floor stations in every instance have the shortest season, while the longest seasons are found either on the slope or at the summit. The base stations located on valley floors where the minimum temperature averages especially low during nights of inversion have short growing seasons as compared with slope stations having approximately the same elevation. Thus, Highlands No. 3 has a much shorter season than the stations on the slopes and even at the summits in other groups. As stated before, the length of the season at this station, having an elevation above sea level of 3,670 feet, is only 117 days, and this is in strong contrast with the summit station at Ellijay, about 15 miles distant and having an elevation of 4,000 feet, which has a growing season of 185 days. The base station, Blantyre No. 1, 2,090 feet above sea level, a cold station, has a season 161 days in length, shorter than all slope and summit stations having the same or even greater elevation and 24 days shorter than the summit station at Ellijay, almost 2,000 feet higher.

It would be important if the exact relation between the length of the growing season and the elevation could be determined, but there are complications that prevent a solution. A comparison generally throughout the region is difficult because of the great variation in the topography.

Moreover, the figures in Table 24 indicate at a glance the necessity for longer records to determine the average length of the growing season. For instance, at Highlands No. 3, which has the shortest season, 117 days,

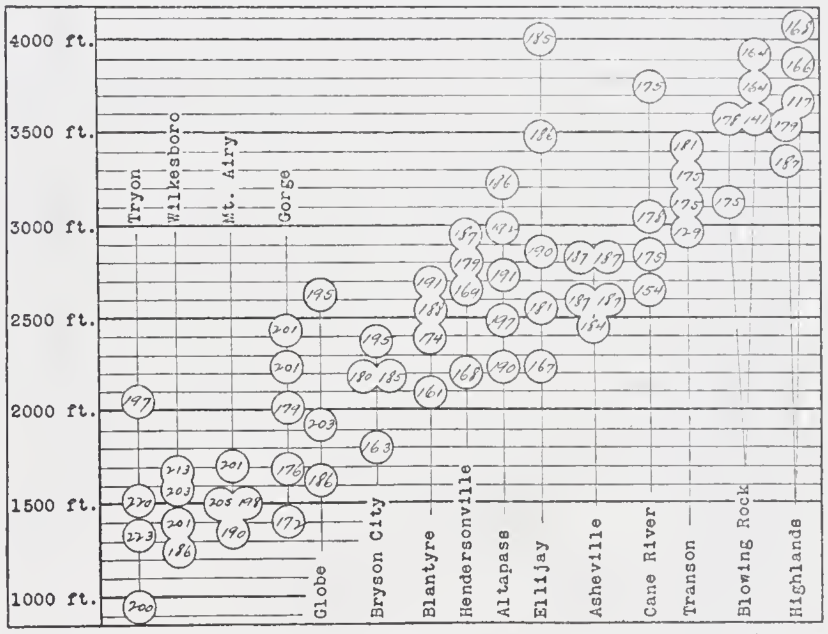

FIG. 78.—Length of growing season; stations grouped according to elevation above sea level.

within the four-year period, one of the seasons, 1915, has a length of 135 days, while another, 1913, only 100 days. The four-year average at he base station at Tryon is 200 days, and the range during that period is 31 days, one season, 1915, having 213 days, and another, 1913, only 182 days. Again, at the base station at Cane River there is a range during the four years of 39 days, and this is exceeded at Blowing Rock Nos. 4 and 5 and at Transon No. 1, where the range amounts to 55 days, the greatest of all. Hence it must be apparent that the average for the four-year period only can not be considered without qualification, and a period of 15 or 20 years is necessary in order to establish true average values.

In making any comparison of stations in different groups due allowance has to be made for difference in latitude, and in this connection reference should be made to Mr. P. C. Day's paper[12] which indicates that there is a normal difference of about 15 days in the growing season between the northern and the southern boundaries of western North Carolina. Thus normally, Highlands, near the southern border, would have a growing season 15 days longer than places near the northern border having the same elevation, and yet the coldest station at

[12] Frost Data of the United States, Bulletin V, U. S. Weather Bureau. *See also* Atlas of American Agric., frost folio, etc.

Blowing Rock No. 3, has an average growing season 24 days longer than station No. 3 at Highlands in the frost pocket, although there is only about 100 feet difference in elevation. However, this statement does not mean that Highlands, as a whole, is a cold place, but has reference only to the special conditions at the base of the Waldheim orchard. The slope above No. 3 has a much higher average temperature, with a growing season 50 days longer.

So far as latitude is concerned, the length in days of the growing season gradually decreases northward, but this decrease is offset by the longer day and the larger amount of sunshine during the summer at the more northerly points. At the time of the summer solstice the day along the northern border of this country is about two hours longer than on the coast of the Gulf of Mexico, while at intermediate points the differences are, of course, much less, aside from the gradual shortening of day on both sides of the solstice. For instance, the average length of day during the growing season in North Carolina is approximately 30 minutes shorter than in the North Atlantic States.

TABLE 24.—*Length of growing season.*

Principal and Slope station; elevation of base stations above mean sea level (feet).	Height of slope stations above base (feet).	a	b	c	d	e	f	g	h	i
Altapass:										
No. 1 (base) Elevation 2,230		Apr. 10	Oct. 2	Apr. 8	Oct. 15	Apr. 4	Oct. 28	201	175	190
No. 2, SE	250	Apr. 21	Oct. 9	Apr. 12	Oct. 26	...do.....	Nov. 15	219	188	197
No. 3, SE	500	...do.....	Oct. 10	...do.....	Oct. 20	...do.....	Oct. 27	195	189	191
No. 4, SE	750	...do.....	Oct. 9	Apr. 16	Oct. 25	...do.....	Nov. 15	219	175	192
No.5, Summit	1,000	Apr. 27	...do.....	...do.....	Oct. 19	...do.....	Oct. 27	194	174	186
Asheville:										
No. 1 (base) elevation 2,445		Apr. 21	Oct. 2	Apr. 14	Oct. 15	Apr. 10	...do.....	200	175	184
Wo. 2, N	155	Apr. 28	Oct. 9	Apr. 16	Oct. 20	Apr. 4	...do.....	195	176	187
No. 2a, S	155	...do.....	...do.....	...do.....	...do.....	...do.....	...do.....	195	176	187
No. 3, N	380	...do.....	...do.....	...do.....	...do.....	...do.....	...do.....	193	176	187
No. 3a, S	380	...do.....	...do.....	...do.....	...so.....	...do.....	...do.....	195	176	187
Blantyre:										
No. 1 (base) elevation 2,090		May 20	Sept. 22	Apr. 30	Oct. 8	Apr. 19	Oct. 28	173	153	161
No. 2, NW	300	Apr. 21	...do.....	Apr. 16	Oct. 7	Apr. 10	Oct. 27	189	154	174
No. 3, NW	450	...do.....	Oct. 9	Apr. 12	Oct. 17	Apr. 4	...do.....	190	185	188
No. 4, NW	600	...do.....	...do.....	...do.....	Oct. 20	...do.....	...do.....	194	188	191
Blowing Rock:										
No. 1 (base) elevation 3,130		May 11	Oct. 1	Apr. 22	Oct. 14	Apr. 10	...do.....	189	162	175
No. 2, S	450	...do.....	Oct. 9	...do.....	Oct. 17	...do.....	...do.....	189	162	178
No. 3, SE (base)	450	May 20	Sept. 20	May 5	Sept. 23	Apr. 18	Sept. 27	158	130	141
No. 4, SE	625	May 11	Sept. 22	Apr. 26	Oct. 7	Apr. 15	Oct. 27	189	134	164
No. 5, SE	800	...do.....	...do.....	...do.....	...do.....	...do.....	...do.....	189	134	164
Bryson:										
No. 1 (base) elevation 1,800		May 12	Sept. 22	Apr. 28	Oct. 8	Apr. 19	Oct. 28	190	133	163
No. 2, N	385	Apr. 21	Oct. 2	Apr. 11	Oct. 13	Mar. 29	...do.....	199	175	185
No. 2a, S	385	Apr. 28	...do.....	Apr. 16	...do.....	...do.....	...do.....	199	157	180
No. 3, summit	570	Apr. 21	Oct. 9	Apr. 8	Oct. 20	Mar. 28	...do.....	206	188	195
Cane River:										
No. 1 (base) elevation 2,650		May 20	Sept. 23	May 5	Oct. 6	Apr. 19	Oct. 27	173	134	154
No. 2, N	190	May 11	Oct. 2	Apr. 22	Oct. 14	Apr. 11	...do.....	189	162	175
No. 3, NE	400	Apr. 29	...do.....	Apr. 19	...do.....	...do.....	...do.....	189	174	178
No. 4, summit	1,100	...do.....	Sept. 30	Apr. 22	...do.....	Apr. 13	...do.....	189	156	175
Ellijay:										
No. 1 (base) elevation 2,240		Apr. 28	Sept. 22	Apr. 24	Oct. 8	Apr. 18	Oct. 28	190	148	16
No. 2, N	310	Apr. 21	...do.....	Apr. 10	...do.....	Apr. 6	...do.....	190	169	181
No. 3, N	620	...do.....	Oct. 9	Apr. 12	Oct. 19	Apr. 4	Oct. 27	193	188	190
No. 4, N	1,240	Apr. 28	...do.....	Apr. 16	...do.....	...do.....	...do.....	194	175	186
No. 5, summit	1,760	Apr. 27	...do.....	Apr. 17	...do.....	...do.....	...do.....	189	177	185
Globe:										
No. 1 (base) elevation 1,625		Apr. 22	Oct. 10	Apr. 17	Oct. 20	Apr. 10	Oct. 28	195	178	186
No. 2, E	300	Apr. 11	...do.....	Apr. 6	Oct. 26	Mar. 28	Nov. 15	219	189	203
No. 3, summit	1,000	Apr. 21	...do.....	Apr. 8	Oct. 20	...do.....	Oct. 27	207	188	195
Gorge:										
No. 1 (base), elevation 1,400		May 12	Oct. 2	Apr. 27	Oct. 16	Apr. 16	Oct. 28	190	157	172
No. 2, NE	290	May 11	...do....	Apr. 22	Oct. 15	Apr. 10	...do....	190	163	176
No. 3, S	615	...do....	...do....	Apr. 19	...do....	Apr. 4	...do....	190	163	179
No. 4, N (old)	840	Apr. 21	Oct. 10	Apr. 8	Oct. 26	Mar. 29	Nov. 15	219	189	201
No. 4, NE. (new)	840	...do....	...do....	...do....	...do....	Mar. 28	Nov. 16	220	189	201
No. 5, summit	1,040	...do....	...do....	...do....	...do....	...do....	...do....	220	189	201
Hendersonville:										
No. 1 (base), elevation 2,200		Apr. 30	Sept. 22	Apr. 23	Oct. 8	Apr. 19	Oct. 28	190	153	168
No. 2, E	450	Apr. 28	...do....	Apr. 22	...do....	Apr. 14	Oct. 27	189	147	169
No. 3, E	600	...do....	...do....	Apr. 16	Oct. 12	Apr. 4	...do....	194	147	179
No. 4, summit	750	...do....	Oct. 9	...do....	Oct. 20	...do....	...do....	194	176	187
Highlands:										
No. 1 (base), elevation 3,350		...do....	Oct. 10	...do....	...do....	...do....	...do....	194	175	187
No. 2, SE	200	...do....	Sept. 22	...do....	Oct. 12	...do....	...do....	193	147	179
No. 3, SE	325	June 14	Sept. 21	May 29	Sept. 23	May 10	Sept. 26	135	100	117
No. 4, SE	525	Apr. 29	Sept. 22	Apr. 20	Oct. 3	Apr. 5	Oct. 27	189	146	166
No. 5, SE	725	...do....	...do....	Apr. 22	Oct. 7	Apr. 13	...do....	189	146	168
Mount Airy:										
No. 1 (base), elevation 1,340		Apr. 21	Oct. 10	Apr. 11	Oct. 18	Apr. 4	Oct. 28	201	184	190
No. 2, W	160	Apr. 10	...do....	Apr. 4	Oct. 26	Mar. 28	Nov. 15	219	189	205
No. 3, E	160	Apr. 21	...do....	Apr. 11	...do....	Apr. 4	...do....	219	184	198
No. 4, summit	360	Apr. 10	...do....	Apr. 8	...do....	Apr. 5	...do....	219	189	201
Transon:										
No. 1 (base), elevation 2,970		June 11	Sept. 20	May 17	Sept. 23	Apr. 18	Sept. 27	158	103	129
No. 2, W	150	May 11	Oct. 2	Apr. 22	Oct. 14	Apr. 11	Oct. 27	189	162	175
No. 3, W	300	...do....	Oct. 1	...do....	...do....	Apr. 10	...do....	189	162	175
No. 4, summit	450	...do....	Oct. 9	Apr. 19	Oct. 17	Apr. 4	...do....	189	162	181
Tryon:										
No 1 (base), elevation 950		Apr. 27	Oct. 21	Apr. 16	Nov. 2	Apr. 5	Nov. 16	213	182	200
No. 2, SE	380	Apr. 10	...do....	Mar. 30	Nov. 8	Mar. 23	...do....	232	207	223
No. 3, SE	570	...do....	...do....	...do....	Nov. 5	...do....	Nov. 15	226	207	220
No. 4, SE	1,110	...do....	Oct. 9	Apr. 6	Oct. 20	Mar. 28	Oct. 28	207	188	197
Wilkesboro:										
No. 1 (base), elevation 1,240		Apr. 22	Oct. 11	Apr. 15	Oct. 18	Apr. 11	...do....	200	177	186
No. 2, N	150	Apr. 11	Oct. 10	Apr. 6	Oct. 24	Mar. 29	Nov. 8	212	189	201
No. 3, N	350	Apr. 10	...do....	...do....	Oct. 26	...do....	Nov. 15	219	189	203
No. 4, W	430	...do....	Oct. 20	...do....	Nov. 5	...do....	Nov. 16	226	201	213

(a) Date of last freezing temperature in spring during four-year period.
(b) Date of first freezing temperature in autumn during four-year period.
(c) Four-year average date of (a).
(d) Four-year average date of (b).
(e) Earliest date of last freezing temperature in spring during four-year period.
(f) Latest date of first freezing in autumn during four-year period.
(g) Length in days of longest growing season, or interval between (a) and (b) of same year.
(h) Length in days of shortest growing season, or interval between (a) and (b) of same year.
(i) Average length of growing season, or interval between (c) and (d).

FRUIT GROWING IN THE CAROLINA MOUNTAIN REGION AND PERCENTAGE OF CROPS, 1913–1916.

Apples and peaches are the principal fruits grown in the mountain region, apples largely predominating. The peaches are generally raised successfully at the lower elevations ranging from 1,000 to 2,000 feet, as at Mount Airy, Wilkesboro, and Tryon; but at higher elevations there is usually considerable danger to the buds on account of winter-killing and spring frosts, and at an altitude of 3,000 feet most varieties of peaches seldom reach maturity. Generally speaking, there were good crops of peaches in 1914 and 1915, but even in the lower levels the peach harvest was only poor to fair in 1913 and 1916, the damage in the latter year being due to winter-killing.

Apples have been raised successfully at the lower and middle levels, but thus far no satisfactory crops have been grown at an elevation as high as 4,000 feet, and 3,500 feet seems to be the limit, especially in the northern portion of the area. Above that level the season is too short and insufficient for the maturing of the fruit, even though there be no damage from winter-killing or spring frosts. On this account, apples grown in the higher levels, with the exception of those especially adapted to the climate, seldom reach full size. The winter apple of the higher altitudes becomes the fall apple at the lower levels, though its shape is sometimes so different that it cannot at first be recognized. At the middle levels apple growing, because of the later blooming in the spring and the comparative hardiness of the fruit, meets with much greater success than that of peaches, as shown by the seasons of 1913 and 1916, when the peach crop at those levels was practically a complete failure, although there was generally a good crop of apples. In fact, in 1916 Bryson raised a full crop of apples. Nevertheless, there is danger to the apple buds, as well as to the peach buds, in the winter and spring because of freezes following long periods of warm growing weather.

Other fruits are raised in the region, but they are of little consequence, with the exception of grapes, and these find the conditions best adapted to their development in the lower levels, and especially in the Tryon area, where this crop during the four years of the research attained large proportions.

In the upper part of the Waldheim orchard at Highlands, the highest point at which observations were made during the period of the research, with an elevation above sea level of 4,075 feet, the conditions so far as the HF° and the length of the growing season are concerned (see Table 25), seems to be exceptionally favorable when they are compared with the conditions at the base of the orchard, 500 feet lower down in the frost pocket at station No. 3, because the higher position has access during nights of inversion to a relatively large amount of free warm air in proportion to the area of radiating surface as compared with the lower position.

However, taking the two orchards at Highlands together, ranging from an elevation of 3,350 feet at the base of the Satulah orchard to 4,075 feet at the top of the Waldheim orchard, the fruit crops during the four years of the research were very small. The peach crop can be considered negligible. The apple crop averaged about 45 per cent, ranging from 25 per cent in 1913 to 65 per cent in 1915, the loss, however, not being entirely due to low temperature, but in some cases to hail, especially in 1913 and 1916.

As compared with Highlands near the southern border of the State, the China and Flat Top orchards at Blowing Rock, another high-level place located far to the north, show even lower temperature conditions, the HF° being greater and the length of the growing season less (Table 25) if we except the record at station No. 3 at Highlands, which is really not a part fo the Waldheim orchard, but rather immediately below it, therefore not representing true orchard conditions. The percentage of the apple crop during the four years at Blowing Rock averaged much lower even than at Highlands, and this in spite of the fact that the orchards at Blowing Rock are given better attention through personal supervision of the manager. Yet the average crop for the four years was only 35 per cent, and in 1915 it fell to as low as 5 per cent, the damage being partly due to hail; but low temperature was the principal cause. The China orchard at Blowing Rock, in which stations Nos. 1 and 2 are located, ranging in elevation from 3,130 feet to 3,580 feet, is much better situated than the Flat Top orchard, where the elevation ranges from 3,580 feet to 3,930 feet, as shown by the figures in Table 25, the crop in the latter often being almost negligible. Although the temperature is raised occasionally by the mountain breeze during nights of inversion on the floor of the Flat Top orchard, this property, as a whole, is cold. Some attempt has been made to raise peaches at Blowing Rock, but in practically every instance the buds were killed in the spring by hard freezes.

Moreover, Transon, also located far to the north, has been referred to as a location having low temperature because of its position on an elevated plateau reaching from 2,970 feet above sea level to 3,420 feet. The figures in Table 25, showing the number of HF° and the length of the growing season, bear out this statement. Here in 1913 and 1915 the apple crop was a complete failure, and only in 1914 was there a heavy yield.

Ellijay, ranging from 2,240 feet to 4,000 feet in elevation, another of the high-level places and one which ranks next to Highlands in elevation so far as the position of its summit station is concerned, is favored with the best conditions meteorologically of the four places, as shown by the figures in Table 25, and especially on its slope from stations Nos. 2 and 4, where the orchard trees are planted. Nevertheless, even there the apple crop during the four-year period did not average more than 55 per cent, the best season being in 1916, with an average of 95 per cent, while in 1913 and 1915 the average was as low as 25 per cent. In 1913 the buds were killed in the freeze of March 27, while the exact dates of damage in 1915 could not be determined. Some peaches are grown at Ellijay on the slope in the vicinity of station No. 3 at an elevation of 2,960 feet above sea level. A fair crop was raised there in 1914 and 1915, but in 1913 and 1916 the crop was a complete failure, in 1913 on account of the freeze of March 27, and in 1916, the freezes of March 16 and April 9.

In the orchard at Cane River, reaching from slightly above the base station No. 1, 2,650 feet, up the slope to approximately 3,100 feet above sea level, the best crop of apples was harvested in the year 1914, when the yield was 85 per cent. However, while the weather conditions in 1916 at that place were especially favorable, the crop amounted to only 65 per cent because of the failure of the owner to spray the trees properly. The seasons of 1913 and 1915 were well-nigh complete failures, 10 per cent and 20 per cent, respectively, in the former year because of the freeze of March 27–28, while in the latter year the dates of damage could not be determined.

The altitude of the portion of the slope at Altapass upon which fruit trees are planted varies from 2,500 to

about 3,100 feet above sea level. A new apple orchard was planted there in 1911, but there are some seedlings and peach trees that have borne fruit intermittently. The new apple trees had not come into bearing at the time of the close of the research, and the seedlings and peach trees had borne fruit rather indifferently. The best year for apples was in 1914, when the crop amounted to 80 per cent, and for peaches in 1915, with a yield of 80 per cent also. Practically no apples or peaches reached maturity in 1916, and in 1913 the yield of both crops was low. This slope is rather cold, because of the large surface area near the summit. It is also rather steep and suffers considerably from washing of the soil during heavy rains.

In the Hendersonville orchard, which ranges in elevation from 2,600 to about 3,000 feet above sea level, the principal crop is apples, there having been no attempt made to raise peaches. There was no yield of apples, even, in 1913, because of the freeze of March 27–28, and in the ensuing three years the yields varied from 20 per cent to 50 per cent. The damage in 1914 was due to freezes and droughts and in 1916 to the severe freeze of February 14.

In the orchard at Asheville, which is on a northerly slope ranging from 2,450 to 2,835 feet above sea level, apples are grown chiefly, but these crops thus far have never been large. The yield in 1913 was only 5 per cent; in 1914, 25 per cent; in 1915, 50 per cent; and in 1916, 55 per cent. The damage in 1913 was caused by killing of the bud in the freeze of March 27–28 following a period of high temperature. Various reasons are ascribed for the results in 1914 and 1915, while in 1916 the freeze of April 9–10 and of March 16 were the principal factors. The upper portion of this orchard, located as it is upon a northerly slope with heavy timber above (see fig. 18), suffers from too much shade. The owner believed that, for some reason, there was deficient pollination in that section, and he tried to correct it through the use of bee swarms, but this method did not meet with success. As a matter of fact, a certain amount of sunlight is absolutely necessary for the growing of fruit, aside from the fact that low day temperature is involved.

TABLE 25.—*Length of growing season and number of hour-degrees of frost at high-level stations—Blowing Rock, Ellijay, Highlands, and Transon.*

Principal and slope stations; elevation of base stations above mean sea level (feet).	Height of slope stations above base (feet).	a	b
Blowing Rock:			
No. 1 (base), elevation 3,130	....	175	285
No. 2, S	450	178	292
No. 3, SE. (base)	450	141	345
No. 4, SE	625	164	316
No. 5, SE	800	164	339
Ellijay:			
No. 1 (base), elevation 2,240	....	167	241
No. 2, N	310	181	195
No. 3, N	620	190	189
No. 4, N	1,240	186	210
No. 5, summit	1,760	185	251
Highlands:			
No. 1 (base), elevation 3,350	....	187	166
No. 2, SE	200	179	195
No. 3, SE. (base)	325	117	367
No. 4, SE	525	166	270
No. 5, SE	725	168	261
Transon:			
No. 1 (base), elevation 2,970	....	129	295
No. 2, W	150	175	303
No. 3, W	300	175	281
No. 4. summit	450	181	283

(a) Length of growing season in days based upon the average interval between the date of last occurrence of 32° in spring and the first occurrence in autumn during the period from 1913–1916, inclusive.

(b) Total number of hour-degrees of frost during selected periods of both inversions and norms.

The orchard at Blantyre is a part of the State farm, and it therefore has received more attention in a scientific way than most other orchards in the North Carolina region. Peaches have been grown on that property in the vicinity of the base station at an elevation of 2,100 feet above sea level, but the yield has been rather indifferent, although an excellent crop was raised in 1915, with a percentage of 90. The yield amounted to only 5 per cent in 1916, when the buds were winter-killed by the freeze of February 3 and 14. The apple orchard is situated higher up on the northerly slope of Little Fodderstack at an elevation ranging from 2,400 to 2,700 feet above sea level. There was no yield of apples whatever in 1913 because of the freeze of March 27–28. The crop averaged 50 per cent in 1914 and 1916, and only 15 per cent in 1915. Blight is given as the principal reason for the low yield in 1915.

In the orchard at Bryson, which is located far to the west in the middle levels of the mountain region, with its base station 1,800 feet above sea level, there were exceptionally large crops of both apples and peaches in 1914 and 1916, the yield of both being practically the maximum possible in those years. Bryson did not suffer from injury in 1916 like several other sections, apparently because the temperature during the winter was more uniform. There was, however, some damage to peaches on April 10 of that year. In 1913 the apple crop amounted to only 20 per cent on account of the severe freeze of March 27, which killed nearly all of the buds, and in 1915 there was a fair crop, 50 per cent, the deficiency being attributed to the heavy crop of the previous year rather than to damage from weather conditions.

Mount Airy, whose base station is 1,340 feet above sea level, located in the eastern foothills of the mountain region well to the north, seems to have an especially favorable position from a climatic standpoint, and there apples and peaches are raised with equal success on the slope reaching up to the knob 360 feet. The average yield during the four-year period was 70 per cent and 75 per cent, respectively. In 1913 there was some damage from hail in May to both apples and peaches. In 1915 the weather conditions were excellent, but there was damage to apples by twig blight. In 1916 the peach crop fell to its lowest point, 30 per cent, due to winter-killing on February 14.

On the portion of the slope at Tryon ranging from 950 feet above sea level at the base to 1,520 feet at station No. 3, the climatic conditions are especially favorable for the raising of fruit, the apple crop during the four-year period averaging 80 per cent and the peach crop 70 per cent. Tryon has some of the finest vineyards in the country at an elevation of 250 to 600 feet above the valley floor and approximately 1,150 to 1,500 feet above sea level. The vineyard in which the research stations were located reported practically a full crop of grapes for the four years, averaging 99 per cent. The center of the thermal belt on the Tryon slope, as already states, is especially low, and this fact, together with the southerly location, insures most highly favorable temperature conditions for fruit growth.

The weather conditions at Wilkesboro are much the same as at Mount Airy, and no special mention of the fruit yield there need be made. No fruit of consequence has ever been raised at either Globe or Gorge on account of the rocky formations and poor soil conditions. The temperature on the upper half of the Gorge slope is as favorable for fruit growing as any in the Carolina mountain region, but it has been most difficult to clear the

ground on account of the large number of rocks and bowlders.

While the discussion of the yields in the foregoing paragraphs in the various orchards where research stations were maintained has mainly to do with weather conditions, it should be obvious that failures may in many cases be charged to other causes. The varying temperature, of course, is the principal factor meteorologically in its effect upon the yield of fruit, but the question of precipitation is also often involved. It is seldom that droughts occur in the mountain region, but nevertheless dropping in some sections has been ascribed to drought, especially in 1913 and 1914 during May. On the other hand, excessive precipitation is frequently injurious in that it sometimes prevents necessary spraying, including that for fungus diseases. Moreover, excessive precipitation invites fungus growth. Hail, too, often causes serious damage, especially in the higher elevations and in the southern portion of the region.

Moreover, some of the orchards receive far better care from a scientific standpoint than others, the growers following the instructions from the State horticulturist and the Agricultural Experiment Station more or less conscientiously. The percentages of average yields, therefore, do not necessarily indicate whether the meteorological conditions were favorable or unfavorable, except in a general way. For instance, it is hardly fair to compare from a meteorological viewpoint the yield of the orchard at Mount Airy, which receives the best possible attention, with those in other sections, which are more or less neglected.

The conditions shown for any four-year period, of course, are not necessarily the average for the region, and it is possible that over a long term of years greater average success would be attained in the growing of fruit than the figures in this publication would indicate. Moreover, no artificial means for raising the temperature on critical nights through the use of heaters had been tried, nor is such a plan practicable because of the topography of the region, except in a few instances.

FRUIT GROWING AT HIGH ELEVATIONS IN THE WEST.

Apparently success has been attained in the raising of fruit at much higher levels in the West than in the North Carolina mountain region, but with the aid of orchard heaters. Grand Junction, Colo., for instance, with an elevation above sea level of 4,667 feet, is a fairly representative area in the subarid fruit-growing section. There the mean annual temperature is 51.2°, as compared with 55.1° at Asheville, N. C., at a much lower elevation, 2,255 feet. However, the mean temperatures at these two places do not indicate at all the range of the extremes, the maxima being much higher at Grand Junction and the minima much lower than at Asheville. For instance, in the four-year period of this research the temperature at Grand Junction ranged from a maximum of 100° to a minimum of −19°, while that at Asheville ranged from 94° to 4° above zero. However, the extremes, whether for the year or for the day, are maintained at Asheville, because of the higher vapor pressure, for a longer period than at Grand Junction. In other words, the temperature at Asheville may continue at its highest and lowest points on any day for an hour or two, while at Grand Junction the extremes are only momentary, so that actual maximum and minimum temperature data, for instance, do not by any means indicate the relative number of hour-degrees of frost involved.

CONCLUSION.

It should be apparent from the data presented in the discussion that minimum temperature and its duration are the chief factors involved in the growing of fruit in the North Carolina mountain region, just as they are in any other orchard region, provided, of course, sufficient moisture is supplied through rainfall or irrigation.

However, maximum temperature is often a consideration. It has been shown that the maxima are much higher in the winter on a southerly than on a northerly slope and in all seasons of the year higher on a westerly than on an easterly slope. But relatively high maximum temperatures are not always to be desired. Where the maximum is abnormally high in the winter and spring, so as to force the buds prematurely, there is danger of damage from ensuing frosts or freezes, sometimes in contrast with slopes where the maximum does not rise so high. In any case, shade must be avoided, such as noted in the upper portions of the orchards at both Asheville and Cane River, because it not only prevents necessary sunlight, but also serves to reduce the sensible temperature after precipitation to a lower point than that shown by the thermometer through the retention of the moisture on the vegetation and fruit.

So far as the minima are concerned, it is obvious that great care should be taken in the selection of a site for an orchard. Valley floors must in nearly all cases be avoided. There the temperature on critical nights of inversion often falls 15° or 20°, and sometimes even 25° or 30°, lower than higher up on the slope.

Some valley floors are, moreover, colder than others. Wide floors, such as those at Blantyre and Bryson, surrounded by high mountains at some little distance, where the loss of heat through radiation is quite rapid, are somewhat colder than other floors closely shut in, such as at Ellijay. The latter is not, indeed, warm, but its slightly higher minima as compared with Blantyre and Bryson are due to obstructed radiation, although the area of radiating surface in the immediate vicinity of the closed-in floor is unusually large, but not sufficient to offset the obstruction referred to by raising the sky line.

Valley floors similar to those at Tryon and in the Flat Top orchard at Blowing Rock have been shown to be warm on certain nights of inversion considering their elevation above sea-level, both relatively warmer than Ellijay, and this, too, in spite of the fact that the floor at Tryon, especially, is wide. However, the higher average minima at Tryon, as well as Blowing Rock, are due to the prevalence of the nocturnal mountain breeze down the slope and valley from the great surface area around the summer station. During nights of inversion, when conditions are not favorable for the mountain breeze, the temperature falls at these two places comparatively low.

While the great area above is responsible for the nocturnal breeze and the raising of the minima on the floor, it, at the same time, causes low temperature at the higher levels, because of the large area of radiating surface in proportion to the air available for interchange, so that on such slopes as these two, as well as at Altapass, the upper levels are cold and the valley floors often comparatively warm.

This research has shown that the mountain breeze does not develop at night and flow down a valley unless there is great surface area around the summit station. On no valley floor where the slopes culminate in knobs has the nocturnal breeze been noted. The thermograph traces on the floors at Bryson, Blantyre, Ellijay, Gorge, Cane River, and Mount Airy, all with small mass, never

show any sign of the mountain breeze. Before such a breeze develops, there must be available a relatively large amount of heavier and potentially colder air above. And this can only occur over a plateau-like surface. There is no opportunity for such development over a knob. Where the highest points are mere peaks or knobs, they partake of the temperature of the free air surrounding and are always relatively warm on nights of inversion, and this, too, in spite of the fact that a knob is best situated topographically for loss of heat through radiation, as its angle of free radiation may exceed even 180°.

The descending nocturnal breeze may properly be compared with a waterlike flow as it passes down the slope and mixes with the cold air of the valley floor, and it is entirely unlike the slow exchange of free air over a valley with that resting on a slope. The cold air sometimes collects on benches or coves on a slope, and when great difference in density exists between it and the neighboring free air the cold air slips off and passes down the slope, immediately giving place in turn to warmer air. Such a phenomenon has often been observed at Blantyre on the descending slope near the base of little Fodderstack.

Coves and even shelves or benches on slopes should be avoided so far as practicable in the planting of fruit trees because of the low night minima, making possible the formation of frost there, while other portions of the slope entirely escape.

Many topographical conditions are involved in their effect upon the minima on a slope. Generally speaking, the steeper the slope the warmer it is during nights of inversion. At the same time, if there is a steep slope directly opposite and close by, making the valley deep and narrow, the entire slope will be relatively cold, rather than warm, up to the level where the free air becomes practically limitless, although, as already stated, its base may be warmer than a wide valley floor. If this steep slope has no opposing slope and it culminates in a knob above, it will be relatively warm its entire length. A gradual slope is naturally colder than a steep one, and the nearer it approaches to the level of a plain the colder it is.

On a short slope culminating in a knob no more than 500 feet in elevation the height being insufficient to cause more than a degree or two difference in temperature between valley floor and summit on nights of norm conditions, such as Blantyre, Bryson, and Mount Airy, the summit is the safest section for fruit growing, because during nights of inversion the highest minima are practically always registered at that level. This usually is the case on slopes even up to levels as high as 1,000 feet above the valley floor, as Gorge and Cane River. It has been shown that the center of the thermal belt on some nights of inversion is even as high as the summit of Ellijay, 1,760 feet above the valley floor, and on the average the thermal belt is centered more than 1,200 feet above that floor, due to the fact that the portion of the slope lower down is comparatively cold. However, there is always greater danger from top freeze at the higher elevations of long slopes, and these at Ellijay, for instance, have a greater number of H F° on the average than the level of 600 or 700 feet above the floor. Usually on a slope having an elevation of 1,000 feet or more above its floor the safest level, from the standpoint of the number of H F° from inversion and norm conditions combined, is from 300 to 700 feet, but on slopes having a very small grade and terminating in a knob, as Gorge, the safest point is at the very summit.

Moreover, if the summit at Ellijay were immediately surrounded by great surface area at that level, as at Tryon and Altapass, instead of being on a mere knob, it would be much colder, and this would serve to reduce the temperature generally over its upper levels, so that the level of the thermal belt would be correspondingly lowered and its width reduced to very small limits. Such a slope would indeed be a cold one practically from base to summit, if there were high opposing slopes close by.

While the slopes at Bryson and Blantyre are warm as compared with their respective floors during nights of inversion, they are, nevertheless, relatively cold for their elevation, because they are located in vast frost pockets formed by surrounding mountains which tower above at considerable elevation. Frost pockets must be avoided as far as practicable, whether large or small. The one in the Waldheim orchard at Highlands, a small depression or sink, although much unlike those at Bryson and Blantyre, is nevertheless equally objectionable.

An ideal slope for fruit growing is one of moderate elevation above sea level, the basic altitude varying, of course, in different portions of the country, fairly steep and culminating in a knob with no surrounding mountains, or if any, at least, situated so far distant as to have no effect upon the temperature conditions of the slopes involved, such as Mount Airy and Wilkesboro, or the lower levels of a slope such as Tryon, which is warm because of the absence of opposing slope and because of the influence of the nocturnal breeze, although its upper levels are cold on account of the great area surrounding the summit.

The subject of vegetation must be considered, dense vegetation being responsible for great loss of heat through radiation, and a cultivated orchard is therefore warmer than one planted in grass.

The data presented in this study make plain the necessity for great care in the selection of a property for the purpose of fruit growing. The topography of a region is paramount. Frost pockets should be avoided and valley floors of all kinds as far as practicable, unless means are available for orchard heating. The altitude above sea level is in every case a consideration and, in a degree, the elevation above the valley floor.

All these questions must be given careful consideration and the effect of one upon another weighed in the balance. No hard and fast rule can be made in the determination, as the factors involved are so many and so complicated that each site must be considered by itself.

APPENDIX.

THERMAL BELTS FROM THE HORTICULTURAL VIEWPOINT.

By W. N. Hutt, Former State Horticulturist.

It would be impossible to be associated in any capacity with the growing of fruit in North Carolina and not hear of "thermal belts" or "verdant zones." These euphonious terms (whatever they may mean) are more or less common and usual expressions found daily in the speech of the fruit producers of this State. The outsider, on coming in contact with North Carolina fruit growers, is soon led to inquire, "What are these belts or zones?" "Where are they to be found?" "What are their characteristics?" "Are they found in North Carolina alone?" "Do not other States have them?" This was my experience when, in 1906, I came to North Carolina to begin my work as State Horticulturist. Previous to that time I had been closely associated with the fruit growers of other States, but I am frank to admit that until my coming here I had never heard of a thermal belt or of a verdant zone. But the fact remained that such belts or zones were mentioned frequently by the North Carolina fruit growers, and the practical value of these zones seemed to be in evidence, for a grower was considered very fortunate if he owned one or came even partially under its benign influence.

The practical men who make their living from mother earth in fruits, vegetables, grains, or other products are close observers of nature and her laws. They may not always be able to correctly interpret her ways and define her laws, but if they have observed any phenomenon and formulated any practice from it you may be pretty sure there is something in it, and you will be unwise if you disregard it without investigation. As a horticultural investigator in North Carolina I felt it was my duty to investigate these thermal belts and verdant zones.

To get what definite data I could—not just hearsay—on which to base my researches, I made a study of all available published literature on the subject, and notes therefrom appear in small print at the bottom of these pages. In making my trips over the State and in coming in contact with fruit growers I kept up a constant quest for the elusive thermal belt, but, like an ignis fatuus, light and tenuous as air, it always seemed to elude my grasp. One thing, however, that seemed to stand out clearly was that this will-o'-the-wisp was the tutelary deity of the mountains, less seldom seen in the hills and never showing its form in the plains.

Here seemed to be some explanation why North Carolina has a monopoly of thermal belts: One-third of its area is made up of rolling piedmont hills stretching up to another third, containing the highest elevations east of the Rocky Mountains.

My work as State Horticulturist kept me in contact with the growers and constantly traveling among the orchards at all seasons of the year. I kept careful notes and found that there were peculiar, unaccountable differences in the size of the fruit crops from various localities, and even in the same orchards, where climatic conditions should have been about the same. A wide variation in fruitage was often found in the same varieties. Sometimes in a year when weather conditions were so unfavorable all over the State that it would seem impossible that any fruit would survive some section, or some orchards in a section, would bear a phenominal crop of fruit. A notable case of this kind was in the year 1907, the year of the Jamestown Exhibition. We wished to make there a display of North Carolina fruit throughout the whole season. The spring of 1907 was one of the most unfavorable in years, and it looked as if our exhibition project would have to be abandoned. However, it was found later that there was a good crop of fruit in most of the hillside orchards in the Brushy Mountains in Wilkes and Alexander counties. This and other peculiar phenomena that had been noted throughout the orchards of the mountain regions of North Carolina for four or five years induced me to undertake a definite investigation of this subject.

In 1907, through the State Board of Agriculture, a branch experiment station was located at Blantyre in Transylvania County, N. C., at an altitude of 2,100 feet. The land on this place sloped from river bottom directly up to the top of the Little Fodderstock, including one whole side of the mountain. Though some of this land was steep and in places rocky, we had it cleared and planted in apples and peaches, so that observations could be made on orchard conditions over a wide range of slope and altitude.

In 1911 I had self-recording instruments (hydgothermographs) placed at the different stations in the orchard—at the base, midway of the slope, and at the top of the orchard. The trace-sheet records of these instruments showed a wide variation in temperature during the 24 hours between these different stations, sometimes as much as 10°. This looked very encouraging, for a difference of 1° or 2° of frost at blooming time will make all the difference between success and failure of a fruit crop. How comforting it would be to a fruit grower to know that his orchard or part of it was in a thermal belt with 8° or 10° higher temperature.

From these early observations we learned the most constant characteristic of thermal belts—namely, their variability. Under one set of weather conditions we would find the warmest place in the orchard to be at the bottom of the slope; under another set of conditions at the top, and now again at the middle station.

After two seasons of observations with those three instruments in this one orchard we found it impossible to arrive at any definite conclusions unless we could check and compare our results with instruments in other orchards at different altitudes and on different slopes. This would necessitate the installation of scores of very expensive instruments in a number of orchards at different points. To get anything like accurate records, trained and paid observers would be necessary, and the recording of data would need to be carried on for a number of years. From this it was seen that the problem was much too elaborate and comprehensive to be handled with the facilities and finances then at the disposal of our experiment station, especially when the more simple and practical problems of horticulture were daily demanding attention.

In discussing these problems one day with Mr. L. A. Denson, Section Director for North Carolina, he suggested that we lay the matter before the Chief of the United States Weather Bureau at Washington. Consequently we both made a trip to Washington and discussed the whole matter with Mr. Willis L. Moore, then Chief of the Weather Bureau. Mr. Moore was very much interested in the project and later secured the funds for carrying on the investigation on an extensive scale with the necessary instruments and paid observers at each orchard station. Prof. H. J. Cox, of the Chicago office of the Weather Bureau, was appointed to take

charge of the meteorological side of the work. In July, 1911, a preliminary survey of the orchard region of western North Carolina was made by Professor Cox, Mr. Denson, and the writer and orchards selected for some of the stations. Later in the season, the selected orchards were surveyed and the adjoining territory mapped by F. R. Baker, engineer of the State Department of Agriculture. Mr. Baker also made exact altitude determinations for the instrument recording stations. After this was done Mr. Denson put up the shelters, installed the instruments, and trained the observers in looking after the instruments and in recording other data.

In August, 1912, an inspection trip of these orchard recording stations was made by Professor Cox, Mr. Denson, and myself and additional stations selected that would seem to cover conditions not already met. These additional stations were mapped and instruments installed in them, as described above.

By January 1, 1913, practically all the 16 stations, as shown in the tables that follow, were located, mapped and the observers conversant with the proper handling of the instruments. With orchard altitudes ranging from 956 to 4,067 feet and with every possible slope and declivity, if there is any such thing as a thermal belt it ought to be found and located in this range of varied territory.

The table below gives the accumulated horticultural data for the year 1913.

TABLE 1.—*Summary of horticultural data for season of 1913.*

Location.	Apples. First bloom.	Apples. Full bloom.	Apples. Bloom all shed.	Apples. Duration of bloom.	Apples. Character of bloom.	Peaches. First bloom.	Peaches. Full bloom.	Peaches. Bloom all shed.	Peaches. Duration of bloom.	Peaches. Character of bloom.	Cause of injury.	Date of injury.	Loss by May drop.	Yield of apples.	Yield of peaches.	Altitude.	Range of altitude.
				Days.									Per ct.	Per cent.	Per ct.	Feet.	Feet.
Altapass	Apr. 20	Apr. 29	May 7	17	Light						Freeze	Apr. 28; May 11	25	20		2,230-3,230	1,000
Asheville	Apr. 16	May 1	May 10	24	Very light						Killed in bud by high, cold wind.	Mar. 27-28	Small.	5		2,445-2,825	380
Blantyre	Apr. 21	Apr. 28	May 6	13	Light						Freeze	Mar. 28; Apr. 24; May 12	60	Very small.		2,090-2,690	600
Blowing Rock	May 1	May 8	May 15	15	Heavy						Frost	May 10-11	25	25		3,130-3,930	800
Bryson City					Extremely light.						Killed in bud by high, cold wind.	Mar. 27	Light	20		1,800-2,370	570
Cane River	Apr. 15	Apr. 26	May 7	22	Light on upper slope; average lower.						Top freeze.	Mar. 27; Apr. 28; May 11-12	Very light.	10		2,650-3,750	1,100
Ellijay	Apr. 17	Apr. 20	May 4	27	Light						Killed in bud by high, cold wind.	Mar. 27-28	Heavy.	25		2,240-4,000	1,760
Globe	Apr. 12	Apr. 22	May 2	20	Very light						Cold wind.	Apr. 28; May 11-12		20		1,625-2,625	1,000
Gorge	Apr. 25	May 1	May 7	12	Light						do	Apr. 28; May 11-12	25	25		1,400-2,440	1,040
Hendersonville					Practically no bloom.						Killed in bud.	Mar. 27-28		[1]		2,200-2,950	750
Highlands	Apr. 19	May 1	May 16	27	Heavy								70	25		3,360-4,075	725
Mount Airy	Apr. 10	Apr. 15	Apr. 20	10	Average	Mar. 28	Apr. 3						None.	Heavy.	30	1,340-1,700	360
Transon											Frost	May 11-12		[1]		2,970-3,420	450
Tryon					Average						Dry weather			65		950-2,060	1,100
Waynesville	Apr. 26	May 5	May 15	19	Light						Cold wind.	Mar. 27; Apr. 28; May 11	10	25			
Wilkesboro	Apr. 27	May 10	do	18	Heavy						do	May 11		45		1,240-1,670	430

[1] Almost complete failure.

From this it will be seen that the time of first bloom covered a period of 24 days from April 7 at Ellijay to May 1 at Blowing Rock. The time of full bloom covered 25 days from April 15 at Mount Airy to May 10 at Wilkesboro. The entire range of bloom over the whole territory was 39 days, from April 7 at Ellijay to May 16 at Blowing Rock. The shortest period of bloom at any station was 10 days at Mount Airy and the longest, 27 days, at Ellijay and Highlands.

The bloom period is, of course, the time of injury to the fruit crop. After the fruit sets and the leaves come out the trees become less susceptible to injury as each day passes. In addition to the injurious effects of wind, which will be noted later, it will be seen from the table that two frosts or freezes occurred over the whole territory during the bloom period or shortly thereafter. These were April 22-28 and May 11-12. The minimum readings for the April 22-28 storm at the different stations were as follows:

TABLE 2.—*Temperatures at different slope stations, freeze of April 22-28, 1913.*

Location.	No. 1, base station. Alt.	No. 1, base station. Temp.	No. 2, on slope. Alt.	No. 2, on slope. Temp.	No. 3, on slope. Alt.	No. 3, on slope. Temp.	No. 4, on slope. Alt.	No. 4, on slope. Temp.	No. 5, top station. Alt.	No. 5, top station. Temp.
	Feet.	°	Feet.	°	Feet.	°	Feet.	°	Feet.	°
Altapass	2,230	35	SE., 250	34	SE., 500	33	SE., 750	32	1,000	30
Asheville	2,445	33	N., 155	32	N., 380	32	S., 155	32	[2] S., 380	32
Blantyre	2,090	26	NW., 300	32	NW., 450	35	NW., 600	36		
Blowing Rock	3,130	32	SW., 450	32	SE., 450	31	SE., 625	32	SE., 800	31
Bryson City	1,800	35	N., 385	34	[1] S., 385	34	570	34		
Cane River	2,650	31	N., 210	33	NE., 400	30	1,100	29		
Ellijay	2,240	32	N., 310	34	N., 620	36	N., 1,240	35	1,760	
Globe	1,625	30	E., 300	34	1,000	37				
Gorge	1,400	29	NE., 290	27	E., 615	31	W., 840	34	1,040	39
Hendersonville	2,200	29	E., 450	30	E., 600	40	E., 750	42		
Highlands	3,350	31	SE., 200	30	SE., 325	29	SE., 525	28	SE., 725	29
Mount Airy	1,340	32	W., 160	35	E., 160	32	360	36		
Transon	2,970	23	W., 150	30	W., 300	31	450	32		
Tryon	950	30	SE., 380	46	SE., 570	47	SE., 1,000	45		
Waynesville	2,900	25	N., 150	30	N., 320	32				
Wilkesboro	1,240	31	N., 150	34	N., 350	38	W., 430	43		

[1] Station No. 2a. [2] Station No. 3a.

The direction of the slope and the height of each station above the base stations are given in the columns before the temperature figures. In columns 3, 4, and 5 if no direction of slope is given before the altitude figure it is a summit station. The interpretation of these data I will leave to the meteorologist. From the horticultural standpoint it will be noted that there were decidedly beneficial thermal conditions on the slopes of the orchard at Blantyre at stations 3 and 4, amounting to 3° and 4° of protection. Station No. 2 at Cane River seems to have 1° of protection in this storm. At Ellijay all the stations above the base were well within the safety range. At Globe, the two hill-side stations had 2° and 5° of safety, respectively. At Gorge the two upper stations had a decided immunity, as also had the two upper stations at Hendersonville. There was frost at Mount Airy at the two basal stations on each side of the ridge, while the middle and top stations were well above freezing. The most remarkable thermal conditions are shown at Tryon, where there were two degrees of frost at the basal station in the valley while the hillside stations Nos. 2, 3, and 4 had 14°, 15°, and 13°, respectively, above freezing. At Wilkesboro there was frost only at the bottom station, with all the hill stations standing well above the danger line. A summing up of these data will show that at 20 hillside stations no frost occurred, while at other points above or below in these same orchards there were freezing conditions that would either have killed or injured the blossoms at this critical time. If no other injury had occurred, the fruit at these 20 stations would have passed safely to a good harvest later. Where the second frost did not occur, as at Mount Airy and Tryon, the conclusions above were shown to be correct. Heavy crops of fruit were gathered at both of these points.

Looking further over the data of the above tables, it would appear that at the high altitudes of Altapass, Blowing Rock, Cane River, and Highlands the fruit at the upper stations was killed by "high top freezes."

Some of the observers reported a frost occurring on May 11–12, but a careful perusal of the instrument trace sheet shows no sign of it in the orchard. It must have been seen by the observers in low places and reported accordingly. However, frost did occur at several of the higher stations, as will be seen from the following table:

TABLE 3.—*Temperatures at different stations in cold spell of May 11–12, 1913.*

Station.	No. 1, base station.		No. 2, on slope.		No. 3, on slope.		No. 4, on slope.		Top station.	
	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.
	Feet.	°	*Feet.*	°	*Feet.*	°	*Feet.*	°	*Feet.*	°
Blowing Rock	3,130	30	SW.,450	31	E.,450	23	E.,625	31	800	31
Bryson City	1,800	31	N.,385	33	[1] S.,385	36	570	42	....	....
Cane River	2,650	30	N.,190	32	NE.,400	33	1,100	33	....	....
Gorge	1,400	30	NE.,290	29	E.,615	31	W.,840	36	1,040	40
Highlands	3,350	43	SE.,200	46	SE.,325	29	SE.,525	39	SE.,725	40
Transon	2,970	25	W.,150	31	W.,300	31	450	32	....	....
Waynesville	2,900	29	N.,150	33	N.,300	35	....	....	....	....
Wilkesboro	1,240	34	N.,150	38	N.,350	41	W.,430	40	....	....

[1] Station No. 2a.

From the table above it will be seen that there is a very cold spot, or "frost pocket," about station No. 3 at Blowing Rock, where the temperature was 9° below the freezing point, while no other station in this orchard showed over 2°. The station at this point is located on the bank of an artificial lake, with a dam and timber on one side and high banks on all other sides. This forms a bowl into which the cold air drains and collects. The results of the hard frost about this station showed a striking contrast with conditions elsewhere in the orchard. Fruit was completely killed about station No. 3 and to an approximate height of 60 feet above it. The observer stated that even the leaves were frozen, and he pointed out signs of this to Mr. Denson and myself when making our inspection of the station on September 19, over four months later.

The results of this injury were in evidence even a year later. In his 1914 report the observer stated "The trees near station No. 3 (for a height of approximately 60 feet) show effect of the damage of May 10–11, 1913. While the bloom was generally heavy elsewhere it was notably light in this portion of the orchard." Within the next 50 feet above there were scattered apples. About station No. 2 in the China orchard some of the trees were full, the yield increasing upward through the orchard. Near the base station, situated in the China orchard at an altitude of 3,650 feet, was a plantation of grapes that at the time of our visit (September 19) were just ripening. They showed a heavy yield of fruit, while apple trees near by had little or no crop. This was doubtless due to the later blooming period of grapes. It is interesting to note that the same varieties of grapes were ripe at Tryon at an altitude of 1,275 feet on August 16, showing a difference in season of one month and three days.

It will be noted that in all of the other orchards showing frost the coldest place was at the bottom station, except at station No. 2 at Globe and station No. 3 at Highlands, nearly all the hill stations showing a high immunity from injury. Station No. 3 at Highlands lies at the bottom of a narrow valley surrounded by timber. The cold air traps in this natural bowl and forms a constant frost pocket. This is abundantly shown by succeeding records. On the night of May 11 the observer at Wilkesboro reports a heavy frost below station No. 1 and above No. 4. This is significant, as frost will not occur unless there is dew, and it is a common observation of thermal belts that they are dewless and frostless. The yields of fruit for the season for the different orchards, as shown in Table No. 1, confirms the frost data as recorded by the instruments and observers. From the records of the instruments and also from the reports of the station and observers it was seen early in the season that the spring of 1913 was a precarious one for fruit. Storm followed storm over the Blue Ridge after a period of nearly three weeks of abnormally warm weather in March. This long warm spell, with temperatures ranging in the sixties, started growth in the tissue and softened the buds, even though it was not apparent at the time. Then followed the storm of March 27-28. No bloom had yet appeared. The earliest record of bloom at any station was at Ellijay on April 7. The other stations followed on after this, with records of final bloom up to May 1 at Blowing Rock. On March 27 following this extended warm spell the temperatures at most of the stations dropped from the sixties to freezing and to 5° to 16° below 32° F. In addition to these low temperatures recorded a hard cold wind swept over the orchards from 24 to 48 hours. This peculiar combination of unfavorable conditions produced a result new to me in all my horticultural experience—namely, that the apple bloom was killed in bud. Where the low temperatures and winds were most severe, the trees dropped off their fruit buds and never bloomed at all. In other places the bloom was sparce and feeble and the fruit dropped early. As a contrast to this, at the Mount Airy station, though the temperature dropped as low as 20°, a heavy crop was produced.

At most of the stations the blasting effects of the hard wind was more injurious than the low temperatures, for almost invariably it was the upper or exposed stations that suffered most. On this subject the observer at Bryson City, Capt. A. M. Frye, reports as follows: "That part of the basin facing south and having unusually good protection from high wind shows an average yield, with quite a number of trees in the lower part full, but the opposite slope in the basin facing north has no fruit."

The observer at Ellijay, Charles G. Mincy, reports: "All fruit on upper slope killed in bud by high, cold, north wind." Mr. Julius Gragg at the Globe station reports: "There is practically no fruit on the upper slopes in this vicinity, but the lower slopes and bottoms in some places show good results, especially where there is good air drainage and protection from wind." The late M. C. Toms, formerly observer at the Hendersonville station, reports upon the 1913 crop as follows: "Almost a complete failure, only a few trees of Mother and Virginia Beauty (late bloomers) with fruit. This orchard is situated above a plain and is exposed for the most part to the full force of the wind at that elevation." Mr. Denson remarked that "It is an interesting comparison to note the results from this orchard and that at Mount Airy, a thousand feet lower, with the protecting wall of the main Blue Ridge, which orchard bore practically a full crop. Mr. Joseph L. Welch, observer at Waynesville, remarks that "The most damage was done on high and exposed points where winds had a fair sweep. Most yield is in low ground and where trees were protected from full force of cold winds."

The season of 1912 was a bumper fruit year in North Carolina. One grower wittily expressed it by saying that "Trees that had been dead for five years were heavily loaded that year." A late spring without frosts following a good "old-fashioned" steady winter gave just the combination necessary to assure a good crop. The apple tree is normally an alternate bearer, because the fruit is borne on twigs that takes two years to develop. So a year of full crop where there has been a heavy drain on the energies of the tree will usually be followed by a weaker bud development and lighter crop the following season. From this it would appear that apple orchards went into the season of 1913 with more or less of a handicap, and the exceedingly light crop harvested in the high mountain sections is undoubtedly due to the weakened bloom being subjected to extreme vicissitudes of weather.

LATE-BLOOMING VARIETIES.

A point of decided horticultural interest and value brought out by these observations is the fact that varieties of apples were found that bloomed from 10 days to two weeks later than the usual standard varieties. These varieties, given in order of their lateness of bloom, are Ingram, Mother, Virginia Beauty, Stark, and Gragg (a local variety). In this decidedly off year for fruit the orchard in which the Asheville observation station is located had a full crop of apples on the Ingram variety, which bloomed two weeks later than other varieties, and on Virginia Beauty, blooming 10 days later, one-fourth of a crop, while other varieties in the orchard only averaged 5 per cent of a crop. There were no Ingram or Mother apples at the Blantyre station, but Virginia Beauty there exceeded all varieties in yield owing to its habit of late blooming. The varieties that gave best yield at Blowing Rock were Mother, Gragg, Stark, Ingram, Virginia Beauty, and Jonathan, nearly all of them late bloomers. Mr. T. G. Harbison, observer at the Highlands station, reports his variety yield as follows: "Ingram (late bloomer), full crop; Northern Spy, Black Ben, and Gano, above average; Ben Davis and Champion, below average; Wealthy, Delicious, and Grimes Golden, scattering."

In 1914 the observer at Blowing Rock reported the varieties Mother and Virginia Beauty as being in bloom there 13 days later than other varieties.

FRUIT REPORT FOR 1914.

The year 1914 was known as "a good fruit year" over practically the whole State. There were no freezes during or following the bloom period, and only 2 out of the 16 observing stations reported any frost. These were at Altapass on April 7 and at Blantyre on April 8.

The first bloom reported on peaches was at Tryon on March 28, and the latest date of first bloom was at Blowing Rock on April 22, 25 days later. The period of full bloom over all the stations lasted from April 2 at Tryon to April 26 at Blowing Rock, a period of 24 days. The last peach bloom reported at any station was at Blowing Rock on May 5. It will be noted that Tryon and Blowing Rock represent the two extremes for early and late bloom and that there is a general difference in altitude between these stations of 2,000 feet. The extreme differences in time range in first apple bloom are found between the same stations, Tryon and Blowing Rock, the first being at Tryon on April 15 and the last at Blowing Rock on May 3, 18 days later. The range of apple bloom over all the stations covered a period of 36 days from April 15 at Tryon to May 21 at Blowing Rock. No frost is reported by any of the observers as occurring within this period. The apple crop of 1914, thus unaffected by frost or cold, turned out to be a heavy one, the only setbacks being from blight and drought. The most extended period of bloom at any station was 23 days for peaches at Blantyre and 22 days for apples at Highlands.

On investigation of the injury to peach bloom reported at Altapass on April 9, the instrument record shows the following minimum temperatures at the different stations: Base, 27°; No. 2, 25°; No. 3, 25°; No. 4, 24°; summit, 22°.

It will be noticed that the warmest place is at the base and the coldest place at the summit station. No apples were in bloom at this time, but in a peach orchard located below No. 3 station on the slope the Elberta peaches (earliest bloomers) were just coming into full bloom. A temperature of 7° below freezing would naturally be very injurious at this time. The observer at this station reports the following peculiar phenomenon: On a 20-acre plot just below station No. 3 in peaches young trees, mostly Elberta, one half was killed, while the other half was in good bearing; trees of the same age and under same method of cultivation; practically no difference in elevation; a very slight rise in the ground between the two sections." In this case there was a very evident thermal belt on the slope, and the upper edge of it had been about halfway up through this peach block, as was shown by a failure of fruit above this line and a good crop below it. During the same cold spell frost was reported at Blantyre, but almost exactly opposite conditions prevailed on the slope stations from those reported above at Altapass. Both the slope stations showed lower minima than either the base or summit stations, and peaches at these points suffered a loss of one-third of the crop.

Table 4.—*Summary of horticultural data for season of 1914.*

Location.	Apples.					Peaches.					Cause of injury.	Date of injury.	Loss by May drop.	Yield of apples.	Yield of peaches	Altitude.	Range of altitude.
	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.	Character of bloom.	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.	Character of bloom.							
				Days.					Days.					P.ct.	P.ct.	Feet.	Feet.
Altapass	Apr. 25	May 1	May 8	13	Averago.	Apr. 5	Apr. 17	Apr. 26	21	Average.	Frost	Apr. 7	Light	80	50	2,230–3,230	1,000
Asheville	Apr. 19	Apr. 29	May 3	14	do	Apr. 9	Apr. 13	Apr. 21	12	do	Drought		Heavy	25		2,445–2,825	380
Blantyre	Apr. 20	Apr. 26	May 6	16	Light	Apr. 1	Apr. 7	Apr. 24	23		(1)	Apr. 8	Light	100	66	2,090–2,690	600
Blowing Rock	May 3	May 8	May 21	18	Heavy	Apr. 22	Apr. 26	May 5	13				Average.	50		3,130–3,930	800
Bryson City	Apr. 16	Apr. 21	Apr. 26	11	do						None		Light	100		1,800–2,370	570
Cane River	Apr. 23	Apr. 30	May 8	15	do						do		do	85		2,650–3,750	1,100
Ellijay	Apr. 17	Apr. 25	May 5	18	do		Apr. 7	Apr. 19			do		do	75	95	2,240–4,000	1,760
Globe	Apr. 21	Apr. 26	May 3	10	do	Apr. 7	Apr. 17	Apr. 24	17				Average.	95		1,625–2,625	1,000
Gorge	Apr. 20	do	do	13	do	do	Apr. 16	do	17		None		do	95		1,400–2,440	1,040
Hendersonville	Apr. 22	Apr. 27	May 5	13	Average.	Apr. 3	Apr. 13	Apr. 20	17		Drought		Heavy	50		2,200–2,950	750
Highlands	Apr. 23	Apr. 29	May 15	22	do	(2)					do		do	50		3,350–4,075	725
Mount Airy	Apr. 20	Apr. 26	May 5	15	Heavy	Apr. 1	Apr. 12	Apr. 21	20	Heavy	do		Average.	80	100	1,340–1,700	360
Transon	Apr. 25	May 4	May 14	19	do	Apr. 20	Apr. 24	Apr. 28	8				Light	95		2,970–3,420	450
Tryon	Apr. 15	Apr. 22	Apr. 29	14	Average.	Mar. 28	Apr. 2	Apr. 12	15		Drougbt		Average.	80	70	950–2,060	1,110
Waynesville	Apr. 18	Apr. 24	Apr. 30	12	Heavy	Mar. 30	Apr. 5	Apr. 15	16		None		Light	70	80	2,900–3,200	320
Wilkesboro	Apr. 16	Apr. 23	May 1	15	Average.	Apr. 3	Apr. 12	Apr. 22	19		do		Average.	80	75	1,240–1,670	430

[1] Apples, none; peaches, frost.

[2] Peaches never bloomed; killed in bud Mar. 2, when temperature dropped to 5° F.

FRUIT CROP REPORT FOR 1915.

The year 1915 in North Carolina was a favorable one for fruit production as far as exemption from cold and frost is concerned, for not a single unfavorable report came from any of the observing stations regarding injurious temperatures. The peach crop was much above the average in all sections of the State, and as the behavior of this tender fruit gives a good index of frost conditions it seems safe to say that there was little or no injury to any class of fruits from unfavorable temperatures. This, while very gratifying to the fruit growers in a practical way, was unfavorable from the standpoint of recording data on thermal belts, and little evidence was forthcoming from the year's records.

The apple crop in the State, even with the uniformly favorable thermal conditions, did not amount to over 40 per cent of a full crop, but the injury was due to drought and especially to twig blight, which was very destructive this year to the apple and pear crop throughout the whole country.

A striking and rather remarkable injury occurred in the orchard under observation at Blowing Rock. The observer, Mr. E. G. Underdown, describes it as follows: "Crop almost a complete failure in home and China orchards. Buds knocked off by extraordinarily heavy hail on April 23 just as they were beginning to swell. The ground was covered with buds, and the hail bruised the trees to such an extent as to effect the prospects for next year. Hail was three to four inches in depth and remained on the ground in places for a week. A light bloom followed in about 10 days, but most of it shed without forming fruit, and the fruit that formed dropped shortly afterwards. Hail did not extend to the Green Park orchard, which bore a fair crop, but there was considerable damage from blight."

Table 5.—*Summary of horticultural data for season of 1915.*

Location.	Apples.					Peaches.					Cause of injury.	Date of injury.	Loss by May drop.	Yield of apples.	Yield of peaches	Altitude.	Range of altitude
	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.	Character of bloom.	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.	Character of bloom.							
				Days.					Days.					P.ct.	P.ct.	Feet.	Feet
Altapass	Apr. 25	Apr. 30	May 5	10	Average.	Apr. 14	Apr. 20	Apr. 25	11	Average.	Blight		Average.	33	80	2,230–3,230	1,000
Asheville	Apr. 22	Apr. 28	May 3	11	do	Apr. 10	Apr. 18	do	15		(1)		Heavy	50		2,445–2,825	380
Blantyro	Apr. 21	Apr. 26	May 9	18	Heavy	do	Apr. 15	May 3	23	Heavy	Blight, drougbt		do	15	90	2,090–2,690	600
Blowing Rock	Apr. 29	May 8	May 12	13	Light to average.	Apr. 18	Apr. 24	Apr. 30	12		Heavy hail	Apr. 23	do	5		3,130–3,930	800
Bryson City	Apr. 19	Apr. 26	May 2	13	Average.	Apr. 8	Apr. 15	Apr. 24	16		Blight and drought.		do	50		1,800–2,370	570
Cane River	Apr. 23	May 2	May 9	16	Heavy	Apr. 14	Apr. 20	May 1	17		Cold wind		Light	20		2,650–3,760	1,100
Ellijay	Apr. 20	Apr. 24	May 4	14	Light					Average.			Heavy	25	80	2,240–4,000	1,760
Globe	do	Apr. 25	May 1	11	do	Apr. 9	Apr. 16	Apr. 26	17	do	Blight		Light	20	75	1,625–2,625	1,000
Gorge	Apr. 19	Apr. 28	May 8	19	do	Apr. 5	Apr. 12	Apr. 27	22	Light	do		do	25	75	1,400–2,410	1,040
Hendersonville	Apr. 20	Apr. 27	May 6	16	Average.	Apr. 10	Apr. 19	Apr. 24	14	Average.	Blight, wind		Heavy	20	35	2,200–2,950	750
Highlands Nos. 1–2.	Apr. 19	do	do	17	do	Apr. 9	Apr. 14	Apr. 20	11	do	Cold wind		Light	65	25	3,350–4,075	725
Highlands Nos. 3–5.	Apr. 26	Apr. 13	May 8	12	do												
Mount Airy	Apr. 10	Apr. 14	May 22	12	do	Apr. 6	Apr. 13	do	14	do	Blight		do	50	100	1,340–1,700	360
Transon	Apr. 24	May 1	May 7	13	Light	Apr. 20	Apr. 25	Apr. 30	10	Light	Blight, wind			5	5	2,970–3,420	450
Tryon	Apr. 10	Apr. 16	Apr. 23	13	Average.	Mar. 27	Apr. 5	Apr. 9	13	Average.			Light	85	90	950–2,060	1,100
Wilkesboro	Apr. 14	Apr. 20	Apr. 28	14	Heavy					Heavy			Very light.	90	95	1,240–1,670	430

[1] Apples, blighted; peaches, uninjured.

THE DANGER PERIOD OF 1916.

The spring season of 1916, as shown by the starting of plant growth at the different stations, was from one to two weeks earlier than in 1915. This, of course, gave that much more time for unfavorable temperatures than would occur in a normal or late season, and for that reason the early spring of 1916 was marked by sharp declines in temperature after growth started, with a resultant lessening of the fruit crop. In February and March previous to the starting of vegetation such low temperatures were recorded that most of the peaches were killed in bud, and the bloom that did come out was scanty and irregular. The earliest bloom of peaches recorded was at Tryon, on March 13, and the latest bloom to start was at Globe, March 28, 15 days later. The earliest date of peach bloom being shed was at Tryon, on April 3, and the latest at Bryson City, April 19. The total length of this most critical period to the crop was 37 days over the whole section and 32 days at Bryson City, which was the longest period at any one point. After the bloom is shed the fruit is more or less protected for some days by the "shuck," which is the dried up calyx tube. Leaves push out rapidly at this time and by increasing growth give greater protection to the fruit as each day passes. At points where the peaches were not entirely killed in February they were injured by exceedingly low temperatures of the cold wave of March 16. The minimum temperatures recorded at the different stations during this storm are shown in the following table:

TABLE 6.

Location.	No. 1, base station.		No. 2, on slope.		No. 3, on slope.		No. 4, on slope.		No. 5, summit.	
	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.	Alt.	Temp.
	Feet.	*Mn.*	*Feet.*	*Mn.*	*Feet.*	*Mn.*	*Feet.*	*Mn.*	*Feet.*	*Mn.*
Altapass	2,230	13	SE., 250	11	SE., 500	10	SE., 750	8	S., 1,000	6
Asheville	2,445	11	N., 155	8	N., 380	11	[1] S., 155	8	[2] S., 380	10
Blantyre	2,090	14	NW., 300	13	NW., 450	12	NW., 600	12	....	....
Blowing Rock	3,130	7	SW., 450	4	SE., 450	5	SE., 625	4	E., 800	2
Bryson City	1,800	11	N., 385	11	[1] S., 385	10	570	10	....	....
Cane River	2,650	8	N., 190	9	NE., 400	8	1,100	2	....	....
Ellijay	2,240	10	N., 310	12	N., 620	9	N., 1,240	6	1,760	4
Globe	1,625	17	E., 300	15	1,000	9	....	....	....	....
Gorge	1,400	17	NE., 290	16	E., 615	14	W., 840	12	1,040	12
Hendersonville	2,200	10	E., 450	10	E., 600	5	E., 750	8	....	....
Highlands	3,360	9	SE., 200	7	SE., 325	6	SE., 525	3	SE., 725	3
Mt. Airy	1,340	16	W., 160	14	E., 160	15	360	14	....	....
Transon	2,970	7	W., 150	6	W., 300	5	450	4	....	....
Tryon	950	19	SE., 380	18	SE., 500	14	SE., 1,000	13	....	....
Wilkesboro	1,240	16	N., 150	15	N., 350	17	W., 430	15	....	....

[1] Station No. 2a. [2] Station No. 3a.

After a glance at these minimum temperatures recorded at the different points the wonder is that any fruit survived at all, especially since some of the bloom had burst or was swelling preparatory to doing so and was therefore in a tender condition. At some of the stations even the maximum temperatures for the 24-hour period were below freezing.

Fruit buds and bloom will often stand a drop in temperature to below freezing if the minimum is not long endured, but when the low temperature is maintained for several hours little or no fruit will survive. At the stations of high altitude where the very low temperatures were recorded the peach crop was a total loss. This happens so often in these altitudes that no attempt is made to raise peaches commercially above an altitude of 2,000 feet. Above this general altitude—that is, in the Blue Ridge plateau—not only the bloom buds but even the trees are sometimes killed outright by low temperatures. In all this region peaches are only grown in gardens and protected places for domestic use. An idea of the low temperatures to which fruit is sometimes subjected in these regions can readily be seen by a comparison of the minimum temperatures recorded in the table above at the high stations—Altapass, Blowing Rock, Ellijay, Highlands, and Transon. It will be noted further that at the before-mentioned stations the lowest temperature recorded was in every case at the summit station. This is an example of what is commonly known in these sections as "high-top freezes."

Some of the fruit growers in these higher sections of the mountains gave experiences they had had with "high-top freezes." While we were locating the observing station in Captain Frye's orchard at Bryson City, he pointed to a flat-topped mountain a thousand or more feet higher than his present location and said "I had an orchard once on top of that mountain, but it was killed out by high-top freezes."

Mr. J. D. Auld, manager of the Farm Life School at Valle Crusis, N. C., reports on May 15, 1916, on their orchard which is located in a valley the floor of which has an altitude of approximately 3,000 feet: "Our Black Ben trees, which are about 12 years old, are cracking around the trunk and the bark is breaking off; will you please advise us how to care for these trees and save them?" These trees were evidently killed by the very low temperature of the cold wave of March 16, reported in the table above.

In 1911, when Prof. Cox, Mr. Denson, and the writer were seeking orchards for comparison at high altitudes, we visited one at Elk Park, N. C., where the owner, Mr. McCowan, pointed out a section where he said apple trees had been killed year after year by high-top freezes. In speaking of the cold injury to trees at these high altitudes, I would not care to leave the impression that there are a great many locations in the mountains where it is impossible to raise fruit, but at the same time it must be recognized that each class of fruits has its altitude limitations. From my extended experience with apple growing in the humid regions I would place the altitude limit for commercial apple growing at about 3,000 feet.

TABLE 7.—*Summary of horticultural data for season of 1916.*

Location.	Apples.				Peaches.				Cause of injury.	Date.	Character of bloom.	Per cent of loss by May drop.	Yield.	Altitude.	Range in altitude.
	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.	First bloom.	Full bloom.	Bloom all shed.	Duration of bloom.							
				Days.				*Days.*					*Per cent.*	*Feet.*	*Feet.*
Altapass	Apr. 18	Apr. 23	May 5	17	Mar. 25	Mar. 31	Apr. 5	11	Winter killing.	Feb. 14, Mar. 16	Light	Average.	Apples, 75 [1]	2,230-3,230	1,000
Asheville	Apr. 12	...do	May 7	25	Mar. 27	Mar. 30	...do	9	....	Feb. 14 Mar. 16	Heavy	Light	55	2,445-2,825	380
Blantyre	Apr. 15	...do	May 6	21	Mar. 23	Mar. 28	Apr. 6	14	Winter cold	Feb. 3 Feb. 14	Average.	30	50	2,090-2,690	600
Blowing Rock	....	....	....	....	....	....	....	....	....	....	....	....	....	3,130-3,930	800
Bryson City	Apr. 6	Apr. 21	May 4	28	Mar. 18	Mar. 30	Apr. 19	32	....	....	Average.	Light	100	1,800-2,370	670
Cane River	Apr. 15	Apr. 24	May 18	33	....	....	....	....	Winter killing.	Feb. 14 Mar. 15	..do	Heavy	65	2,650-3,750	1,100
Ellijay	....	....	....	....	....	....	....	....	....	....	....	....	....	2,240-4,000	1,760
Globe	Apr. 12	Apr. 20	Apr. 30	18	Mar. 28	Apr. 2	Apr. 16	19	Freeze	Mar. 16	....	....	75	1,625-2,625	1,000
Gorge	Apr. 2	...do	May 6	34	Mar. 14	Apr. 1	Apr. 8	25	Frost	...do	Average.	....	80	1,400-2,440	1,040
Hendersonville	Apr. 17	Apr. 23	May 7	20	Mar. 24	Mar. 30	Apr. 6	13	Winter killing.	Feb. 14, Mar. 16, Mar. 28	Heavy	Heavy	50	2,200-2,950	750
Highlands	Apr. 15 [2]; Apr. 22 [3]	Apr. 25; Apr. 30	May 9; May 14	24; 22	....	....	....	....	Drought	....	Average.	...do	50	3,350-4,075	725
Mount Airy	Apr. 13	Apr. 21	May 2	19	Mar. 24	Apr. 5	Apr. 16	23	Winter killing.	Feb. 3, Feb. 14	Light	Average.	Apples, 80; peaches, 30.	1,340-1,700	360
Transon	Apr. 20	May 7	May 18	28	Mar. 26	Mar. 31	Apr. 4	9	Frost	Apr. 28, Apr. 30	....	20	Apples, 50; peaches, 50.	2,970-3,420	450
Tryon	Apr. 5	Apr. 13	Apr. 25	20	Mar. 13	Mar. 25	Apr. 3	21	Winter killing.	Feb. 14	Average.	Light	Apples, 85; peaches, 60.	950-2,060	1,000
Wilkesboro	Apr. 4	Apr. 17	Apr. 28	24	Mar. 14	Mar. 28	Apr. 8	24	Freeze	Mar. 16	....	....	25	1,240-1,670	430

[1] Peaches mostly killed in bud. [2] Stations Nos. 1-2. [3] Stations Nos. 3-5.

FROST POCKETS.

A type of local injury to fruit in contrast to that called "high-top freezes" is found in certain locations, known as "frost pockets." These frost pockets are basin-like depressions of greater of less extent formed by the natural lie of the land or by surrounding hills or mountains. Often the pocket or hollow is accentuated by tall timber, which interferes with wind and natural movements of the air.

During the period of these investigations several of these frost pockets were discovered, not by the observers but by the recording instruments. It was noted that at some certain points the instruments habitually recorded lower temperatures than would seem to be warranted by comparison with the other instruments in the same orchard. A careful check on the clocks and recording pens of the instruments by comparison with mercurial thermometers showed no mechanical or instrument variations, so the persistently lower temperatures must be due to local topographic conditions. A description of these persistently low temperature points will bring out the characteristics of these "frost pockets."

At station No. 3, or the lake station at Blowing Rock, habitually low temperatures were recorded. At this point the instrument is located a few feet above the level of an artificial lake that is surrounded by high, rather steep, sloping banks on three sides and by a dam and high timber on the fourth side. In standing at the instrument shelter the observer finds himself in a deep basin, of which the surface of the lake is the floor, and with steep sides sloping rapidly upward in every direction. When there is a falling temperature and no disturbing wind, the air as it cools settles naturally into this depression, and the coldest place is found at the bottom of this basin. Frost after frost was seen in spring in this pocket when none was in evidence in other parts of the orchard. On June 11, 1913, the temperature at this station dropped to 33°, and frost occurred in this pocket though in no other part of the orchard was the temperature lower than 38°. Attention is here called to the freezing of the fruit and leaves on the apple trees in this pocket on May 10–11, 1913, as recorded for the data of that year on page —. On December 15, 1914, a temperature of −5° was recorded by the instrument in this cold basin.

Another "frost pocket," discovered by the recording instrument from low minimums, was at station No. 3 at Highlands. The instrument here is located in a little open field at the base of the Waldheim orchard. The orchard rises above it on a southeast slope to an altitude of 500 feet. This little field at the base of this high slope is completely surrounded by high timber on all sides. The station at this point is characterized by persistently low temperatures and frost. In his 1915 report the observer at Highlands, Mr. T. G. Harbison, says: "There was nearly a full crop of apples in the lower orchard and a fair crop in the Waldheim orchard except in the lower part near station No. 3". This was in one of the seasons most exempt from frost that we have had in years. On December 15, 1914, the temperature in this frost pocket dropped as low as −7°. On June 12 and 14, 1913, the instrument went as low as 32°, and the same low point was reached on June 10, 1916. Another instrument-discovered frost pocket is the base station at Tryon. This station is located near the Pacolet River in a rather narrow valley surrounded by low hills with high mountains beyond. Low temperatures and frosts were frequent at this point. In the year 1914, when conditions for fruit were the most favorable that we have had in years, the fruit in this frost pocket at Tryon was killed, while on the slopes above it there was a bumper crop. The observer, Mr. W. T. Lindsey, of Tryon, reports: "There were no apples in orchard below near station No. 1; apparently killed by frost." The following year (1915) this frost pocket lived up to its former reputation, and Mr. Lindsey makes almost a similar report to 1914, viz, "Fine crop of grapes, peaches, apples, and figs on main slope. Very few apples on orchard at station No. 1; apparently killed by frost."

The early fruit growers believed that the valleys surrounded by timber to protect from winds were the safest places in which to plant fruit trees, but later experience with such places has confirmed the results of our observations that such places are usually frost pockets and should be avoided. The abandoned orchards found in many such locations is mute testimony to their frostiness and resulting unproductiveness. The interest in these thermal belt observations in the mountains naturally made me keenly observant of frost data when-

ever found. I have thus for years in my work as State horticulturist kept careful note of frost data. A few incidents will serve to confirm the data recorded above. At our experimental substation in the Coastal Plain, we had a sharp frost on a quiet night when peaches were in full bloom. On examining and counting several hundred of the injured blooms only 16 per cent of living pistils were found in a zone 2 feet from the ground, 33 per cent in a zone from 2 to 4 feet from the ground, and 60 per cent of living blooms in the zone from 4 feet to the top of the trees. Later at harvest time practically all the crop was gathered from the upper and very little from the lower branches of the trees. Another season at this experimental substation we had a very late and hard frost that came when the pecans were in bloom. A very conspicuous frost line could be seen on the trees about 10 feet from the ground. Below this line the catkins and half-grown leaves were destroyed as if by fire, but above this line the bloom and foliage were uninjured. Later the only nuts that were gathered were from the tops of the trees above 10 feet. The same phenomenon has been observed in the dewberry section, where a frost line showed two-thirds of the way up on the staked vines, which later fruited only at the tops of the six-foot stakes.

Frost lines are often observed in spring on the natural vegetation in the woods. In the Sandhill section of North Carolina, where the irregular contour of the land gives a great many dips and depressions, frost lines are often seen in spring along the bottoms and "branches" in frost-blackened foliage on the "black jack" oaks. These phenomena have many times been pointed out to me by the peach growers in this section. Such phenomena are often noted by fruit growers in the mountains. Once at Blantyre, before we began thermal belt observations, Mr. Collett, our superintendent, called my attention to a frost band along the side of Fodderstack Mountain. A distinct line of frost-bitten vegetation could be seen along the base of the mountain while higher up the foliage was fresh and green.

In the summer and fall of the year fog lines are often seen in the valleys of the mountains as are snow lines in winter. The temperature in the valley will be lowered sufficiently to condense the moisture in the air up to a certain height, which may be seen from above. The fog will follow this temperature line faithfully into every cove or depression of the hills and will appear on its upper surface as level as a floor. In 1911, when Professor Cox, Mr. Denson, and the writer were making our preliminary survey for locating the thermal observing stations we drove on July 4 from Waynesville to the top of ———— Mountain and stayed over night at the "Eagles Nest" hotel. We had a sunrise call for the morning and were well repaid by rising at this early hour to get the magnificent view. It looked more like a sea or lake than an inland mountain valley, for fog had stratified until it looked like a great body of water below, with islands showing where the higher hills of the valley rose above the level upper surfaces of the fog.

CONCLUSIONS.

A thermal belt is not a fixed and definite zone whose boundaries can at all times be precisely located. Under some combinations of weather conditions it may be at the base of a slope and under another set of conditions at the top. A storm or strong wind may so mix up the air that it may be nonexistent or temporarily lost, but when normal weather, as we understand it, is again restored it is back at home again on its native hillside giving favorable temperatures along the slope. We can not commonly see it except to note its presence in frost, fog, or snow lines, but it is there, for the average temperatures for a year or any long period invariably show that the warmest place is on the hillside somewhere above the base. On long slopes on quiet nights there will often be temperatures from 1° to 14° higher than at top or bottom.

To the fruit grower a thermal belt is a very real thing on a quiet night, when the temperature is falling to the danger point. If his orchard is located on a slope well above the frosty bottoms, yet at an altitude not sufficiently high to reach the realm of high top freezes, his fruit may pass safely through the frosty periods, while elsewhere the crop may be a total failure.

The following letter from Mr. J. B. Horton, of Elkin, N. C., is significant and well worthy of publication here:

> Since coming over here early in July, I have been making inquiry in regard to fruit crop in this county and find only apple orchards planted above frost line have full crop. Most of trees on low land are bearing light crops. I find one orchard that has not failed to bear full crop since planted, perhaps 25 years ago, that has this year 300 bushels of Virginia Beauties and other market apples. The thermal belt, or frost line, is very accurately marked in the apple crop this year, and it occurs to me that now would be a most excellent time for some valuable demonstration work to be done by you and your assistants in your branch of the Agricultural Department. One farmer in this county has a cherry tree through which the frost line passes about half way to the top, and on one occasion a full crop of cherries was produced above and none below the line.

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